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ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES 1906

BY

P. K. BLINN

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The Agricultural Experiment Station

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ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES, 1906

By P. K. BLINN

ALFALFA

Improvement by Seed Selection—The alfalfa seed nursery established in 1905 for the selection and improvement of alfalfa, was given as uniform conditions as possible as to care and irrigation; yet there appeared a marked contrast in the size and the early development of six rows of Turkestan alfalfa in the center of the plat, as compared with four rows of native alfalfa on each side. The Turkestan alfalfa was up three inches high by April 1st, while the native rows had not begun to show above the ground; many of the Turkestan stools would measure six to eight inches in diameter, while the native stools would hardly measure three to four, as they broke through the surface of the ground. The Turkestan was also characterized by wide clover-like leaves, as compared with the native, though this character varied in individual plants.

Each stool in the plat consisted of one plant, the nursery having been thinned to one individual to a place; the rows were 20 inches apart and the plants about the same distance in the rows. Plate 2 shows the contrast in the plat, April 15, 1906.

Owing to the marked superiority revealed in the Turkestan alfalfa, it seemed advisable to begin the work of seed selection with this variety, and as we had secured a selection of seed from the most promising plants in the native rows the previous season, we accordingly cut out the rows of native alfalfa, and also eliminated all undesirable plants in the Turkestan rows.

Plate 3 is a view of 12 rows of new seeding from the seed above mentioned which was added to the nursery this year. During the season a close study was made of the individual plants to determine their variations desirable for seed selection. In the plat of over four hundred plants, sixteen were selected for their special characteristics.

Seed producing tendency was a prime consideration for obvious reasons, for how to get a good yield of alfalfa seed is an important question in Colorado. The variation in this respect of the individual plants in the plat was very marked and exceedingly promising of valuable results; for the results of tests so far, seem to indicate that these variations can be fixed through seed selection.

The following notes indicate the characteristics of the plants from which the seed was selected; in each case the seed was the

*This Bulletin is the report of progress of Mr. Blinn as Field Agent, for 1906. It was not prepared as a bulletin.

product of a single plant and had been cleaned. labeled and saved separately, and the original plant from which it came has been marked.

PART OF REPORT FROM ARKANSAS VALLEY FIELD AGENT

Plant 1.—Yield of seed, 66 grams; fine stems, thick set with leaves; desirable plant for hay; seed irregular in ripening; bloom, green pods and ripe seed on the plant at the same time.

Plant 2.—Yield of seed, 45 grams; many fine stems; very little rust or disease on the leaves; seed fairly uniform in ripening; a desirable type for hay.

Plant 3.—Yield, 53 grams; many short, thick stems; seed plump and uniform in ripening; style of stems desirable for supporting seed, but not promising for hay.

Plant 4.—Yield, 24 grams; few long, coarse stems; rust common on leaves; undesirable type.

Plant 5.—Yield, 24 grams; few long stems; seed fairly uniform in ripening, but not desirable for hay.

Plant 6.—Yield, 37 grams; stems long and coarse; seed irregular in ripening; undesirable type.

Plant 7.—Yield, 33 grams; long, coarse stems; seed irregular in ripening; undesirable type.

Plant 8.—Yield, 34 grams; seed head short and small; ripening uniform; not desirable for hay.

Plant 9.—Yield, 40 grams; stems fine; seed very uniform in ripening; a desirable type.

Plant 10.—Yield, 25 grams; a small plant; seed ripened uniformly, with no second growth of stems.

Plant 11.—Yield, 30 grams; stems and leaves free from rust or disease; seed uniform in ripening; a desirable type.

Plant 12.—Yield, 54 grams; fine, large plant; large clusters of bloom; large, uniform seed pods; ripening uniformly; a very desirable plant.

Plant 13.—Yield, 43 grams; fine stems; no rust; uniformly ripe; a desirable type.

Plant 14.—Yield, 41 grams; fine stems; small heads of seed; not regular in ripening.

Plant 15.—Yield, 44 grams; fine stems; no rust on leaves; a desirable type.

Plant 16.—Yield, 55 grams; many fine stems; leaves well retained; seed ripening fairly uniform, while the stems still remained green; very desirable type.

Plant 17.—Yield, 49 grams; seed from a native stool that grew on dry land with no irrigation; had remarkably large flowers that set uniform, with seed that ripened uniformly and was almost perfect in color and plumpness; stems desirable for hay; seed pods on adjacent plants under the same conditions blasted and failed to make seed.

The seed of some of the above plants was selected not for their desirable traits, but to test their future behavior and their reproducing power, and to determine the most potent tendency of the several types.

The average of those that were good seed yielders would amount to over one and a half ounces of clean seed to the plant; this computed for a theoretical yield to the acre, allowing four square feet to the plant, would give one thousand pounds per acre—a yield that does not seem impossible, and one that would be profitable even on highly valued land.

The following, Plate 4, is a view of two adjacent plants as they stood in the nursery row; the one to the left is plant No. 12.

The color contrast of the seed pods was not enough to show

1. A Characteristic Plant of Turkestan Alfalfa.
2. Turkestan Alfalfa Rows Bordered by Common Alfalfa, taken April 15th.
3. Alfalfa Nursery.
4. Two Alfalfa Plants.

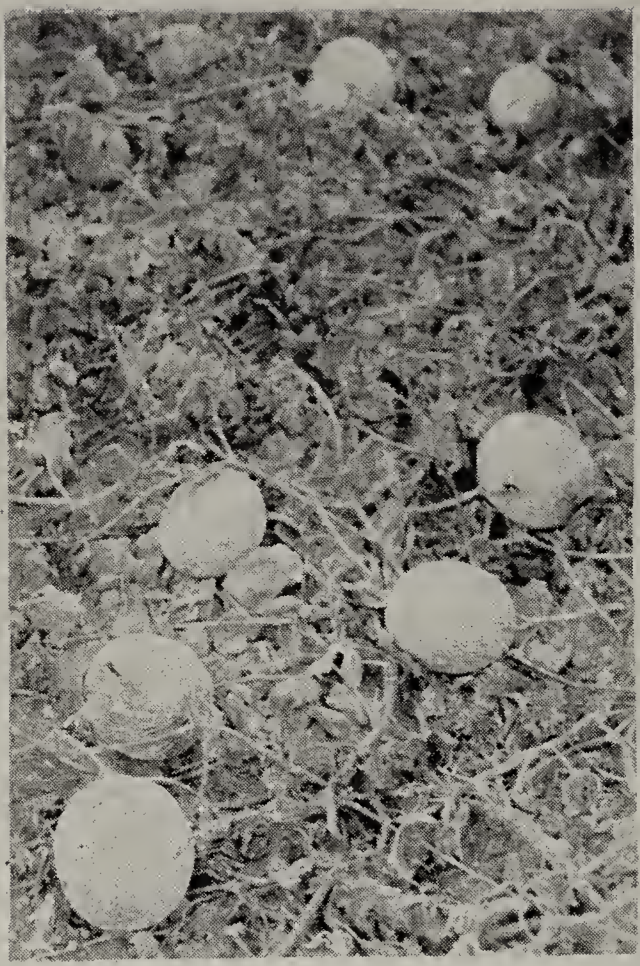

PLATE V.
A Vine Rusted on Check Row.

PLATE VI.
Adjacent Vine Showing Resistance to Rust.

PLATE VII.
Cantaloupe Showing Perfect Netting and Internal Qualities.

the wonderful set of seed as it really was as compared with the plant to the right in the photograph. Both plants had developed under equal conditions in every way, and seemed equally vigorous; both bloomed freely, but while one set seed seemingly at every flower, the other would bloom and blast, which was also the case of the majority of the seeds in the plat; while a few such plants as Nos. 1, 3, 17 and 16 had nearly as much or more seed as No. 12.

Seed Production—In order to determine the conditions most favorable for the production of alfalfa seed, we have instituted a line of personal interviews with some of the most successful alfalfa seed growers, to ascertain their theories and methods regarding the problem; and from such data, together with results of co-operative tests and from our plat work, we hope to determine some of the factors that influence a yield of alfalfa seed, and thus enable the farmer to secure more profitable returns.

The importance of alfalfa in its relation to crop rotation for maintaining fertility is each year more apparent, as the yield from land continually taxed with beets or other crops is contrasted with the same crops grown on alfalfa sod. The breaking up of the old alfalfa fields and the seeding down of the worn out land each year, is creating a demand for alfalfa seed that bids fair to exceed the present rate of supply; for some reasons the present yield of alfalfa seed, even in the best producing sections, is not as good as in former years; and consequently there has been a steady advance in the price of alfalfa seed; this fact and the somewhat uncertainty of success in re-establishing a stand of alfalfa seems to deter many farmers from adopting a crop rotation that good judgment would seem to suggest that they should.

It is in view of increasing the yield of alfalfa seed and solving some of the difficulties of alfalfa growing, that we have undertaken this line of investigation.

BEETS

Under this topic we have continued efforts to develop a disease resisting beet. We have now about 50 pounds of seed produced from the second generation of mother beets since the selection of seed beets from the "curly top" affected fields of 1903. Since that year the trouble has not appeared in Colorado, and in order to test the merits of our selection at this time, we have sent to Dr. C. O. Townsend of the Department of Agriculture, about 25 pounds of this seed; he agreeing to send it out to portions of California and Utah, where the trouble occurs to some extent each year, and will report to us if the seed possesses any inherent resisiting qualities.

In this connection we have gained considerable information relative to the problem of beet seed growing, the methods and conditions necessary for securing a yield of beet seed. Some of the points that have grown out of our experience in this line might be summarized as follows:

1. In a general selection of mother beets for growing seed, there is a wide variation in the seed producing tendency of individuals, and by selecting along this line, our tests have demonstrated that the seed yield can be materially increased.

2. So far, in the beet-growing tests there has usually been a large number of beets that would not grow a seed stalk, but only make a vegetating growth of leaves and root; this feature has varied somewhat with seasons, but our tests have indicated that the soil conditions and the manner of setting out the beets are very essential to uniform seed production.

3. Our method of siloing mother beets has been to silo late in the season, selecting only well matured beets of good shape and size, removing the leaves without injury to the center or crown buds, then layer the beets in dry soil in deep, narrow pits, to protect from frost. Ventilation is necessary, also protection from snows and rain finding their way into the silo.

4. Mother beets should be set out early in April, in this section, selecting a fertile soil, well drained, so that moisture conditions may be controlled.

5. To insure uniform conditions in setting out the beets, a deep furrow should be thrown out and still loosening the soil in the bottom of the furrow, the beets may then be set in the furrows with the crown about level with the surface of the ground; the soil may then be thrown to the beets with a small plow or cultivator, then a small stream of water is run on each side of the row which settles the soil around each beet uniformly. After the beets have started, any soil that may cover the crown is carefully removed; frequent cultivation and irrigation are then applied to induce a rapid growth until the seed stalk appears, then less water is necessary, until the seed begins to ripen, when the water should be withheld.

6. After the seed stalks are well developed, hilling up the rows with soil will prevent much breakage by wind or heavy loads of seed; tying the stalks together with twine is also sometimes necessary.

7. The injury from the false chinch bug is less frequent on alfalfa and grain land that has been kept clean from weeds upon which insects thrive. Thus far, mother beets on clean land surrounded by grain of some kind, have not been attacked by the insect. A flock of young chickens or turkeys has proven a protection from grasshoppers when they are cooped on or near the plat of mother beets.

CANTALOUPES

The question of maintaining or improving the quality of the Rocky Ford cantaloupes becomes more pertinent each year, as we hear the unsatisfactory reports of the irregular quality of the product in all the various markets. The many inquiries and requests for seed from the farmers and the experiment stations throughout the melon growing sections of the United States is

evidence of the urgent needs, and the manifest interest in our work of developing a disease resisting cantaloupe. In order to test the merits of our rust resisting selection under various conditions, we have furnished a few seed to all inquirers from various parts of the United States to those who were willing to make the test in a cooperative way.

As our work of selection was only well begun, we could only furnish what might be termed a second grade selection of seed, as the few seed of the first selection was reserved for our own work. The following are brief extracts from the reports that have been received so far at this time:

"The rust-resistant plat furnished fine melons after the other plats were all dead with rust."—E. C. Green, Texas Experiment Station.

"The melon seed received from you this spring, gave the best melons I have had in previous seasons."—J. D. Fraser, Leamington, Ontario.

"I found the Pollock, or rust-resistant melon superior in quality to the others, but many of them grew rather large."—Chas. L. Goodrich, Glendale, Maryland.

"The reports of three growers who tried the seed you sent me, show that this melon was unusually free from rust, although other melons in the immediate vicinity were badly injured by it."—Samuel B. Green, Minnesota Experiment Station, St. Anthony's Park.

"Until about a week ago the vines showed little or no rust, but at the present writing the leaves are badly spotted; the fruit is good size, and the vines may withstand the attacks until after the melons ripen; I think I gave the variety a very severe test, as the seed were planted on soil that a year ago was devoted to the same crop, which was entirely wiped out by the rust."—H. D. Haskins, Hatch Experiment Station, Amherst, Mass.

"The vines from the disease-resistant seed which you sent me, certainly did resist diseases much better than the old Netted Gem."—F. L. Stevens, North Carolina Experiment Station, Raleigh, N. C.

"I ran all other melons out of the hotels with the rust-resistant "Pollock" seed I got from you."—A. Van Wagenen, Sioux City, Iowa.

From twenty-nine reports from growers in New Jersey, who tested the rust-resisting seed that we furnished Byron D. Halsted of the New Jersey Experiment Station, eighteen reported very favorable results; eight reported that they observed no difference, and three made unfavorable reports; the seed furnished for this test was pure "Pollock" strain, which only had had one year's selection for the rust-resistant feature.

The popularity of the cantaloupe as a fruit on the American table does not seem to diminish, nor does the output or the returns to the grower seem to decrease; these facts are unquestionably due to the greater attention being paid to the quality of the seed selected for planting and also the improved refrigerating and marketing facilities. About the only progress the melon growers have made in regard to seed selection, is the almost unanimous selection and use of single strains of seed by the various associations, thus insuring uniformity. In general, they have selected the strains that were early, prolific, uniform, and also desirable in appearance, with little or no attention being paid to disease-resisting tendencies; in fact, some prejudice exists against the rust-resisting strain, as it is thought to be later and less productive than the strains in general use. This apparent lateness of the rust-resistant strain is probably due to abnormal ripening of the other strains, rather than to any inherent lateness in the rust-resistant strain.

The past season proved very favorable for the development of the rust trouble, and the melon fields went down nearly three weeks earlier than usual; our rust-resistant selection remained green until the majority of the fields were dead, and some of the most markedly resistant plants in the plat remained green until frost, this in spite of the fact that the seed was grown on soil that for four consecutive years had been badly infested with rust, the idea being to develop the quality under as adverse conditions as possible, consequently, irrigation was applied in excess to favor the development of the rust. The plat was planted with the seed of nine individual melons, which had passed the rigid test of selection on the same plat the previous season; one row was planted as a "check" row; seed from a very perfect melon, but from a field that had not been selected for rust resistance. The plat developed nicely until about August 15. The season was characterized by frequent showers and heavy dews, and in July the rust spots appeared on all the early melon fields, and when the first picking began, about August 10th, the fields were getting brown with rust, as was also the check row in our plat, while the other rows were comparatively free from rust. The following photographic record represents the relative condition of the vines on the check row and adjacent rust-resisting row on August 20th; the whole plat having received the same treatment in every respect.

When the rust had developed to some extent on the plat (which began at least ten days later than any other plat under equal conditions), the plat was carefully studied, and over one hundred resistant plants were staked and numbered, and each day as the ripe melons were gathered, these were marked with the number of the hill and the seed saved separately and the description made of the qualities of each. At the close of the season, the plat was gone over and notes taken of the rusted condition of the various plants; this revealed the fact that a few of the whole number, had remained resistant later than others. With the system of numbering used, this seed can be identified and used in further developing this important quality.

Careful consideration and a great deal of time has been devoted to selecting melons with a view to improving their keeping qualities, as well as flavor and other qualities desired in a perfect melon. The following photograph reveals some desirable internal and external qualities shown in some of the melons of our selection.

In order to develop early maturity in our rust-resistant strain, we have made arrangements for a co-operative test, by having some of this seed grown in Canada, the product of which will be tested this coming year at Rocky Ford, to indicate the influence of latitude on early maturity.

Some investigational work in regard to the life history of the melon louse, and the means of combatting it was taken up in cooperation with and under the direction of Prof. C. P. Gillette.

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FRUIT GROWERS' ASSOCIATIONS

BY

W. PADDOCK

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FRUIT GROWERS' ASSOCIATIONS

W. PADDOCK

The Western Slope District—The geographical location of Colorado, particularly of the fruit district on the Western Slope, is such that it is necessary for the majority of fruit growers to sell their products through associations. This is especially true since the product of her orchards has become so great that the bulk of the fruit must be sold outside of the State. Here we must compete for the markets, usually at a disadvantage because of high, and many times unjust, transportation rates. Car load lots then must be the unit of shipment, but what is more important, the shipper must know the condition of the markets each day in order to place his produce to the best advantage. It must be apparent that the marketing of fruit requires a high type of business ability, and the average grower has small chance in the markets under these conditions. This was particularly true a few years ago before the associations had become important factors in marketing. Since their advent prices have been much more stable, and the entire section has been benefited thereby. Formerly the grower had no means of becoming acquainted with the condition of the outside market, so he was more or less at the mercy of the buyer.

There is a wide difference between the prices received by the producers of farm products and those which the consumers are compelled to pay. Could the two classes deal directly with each other, the law of supply and demand would control prices and each class would be greatly benefited. However, we can scarcely hope to reach this consummation, but much may be done to better present conditions if the farmers can only grasp their opportunities.

Fruit growers' associations are not new institutions in Colorado. Perhaps in no state east of the Pacific coast have they been more successful or longer in operation. But there are still many localities in the State which are either not organized, or where the existing associations have not been so successful as is desirable. Then there are localities where special crops, other than fruit, are grown where the growers would be greatly benefited by marketing their produce through associations. An attempt is made in the following pages to describe the workings of the fruit associations with the idea of being helpful to those who may be interested in such organizations.

The growing of fruit itself is an intricate business and is usually all that one man should attempt. If he makes a success of orcharding, the time of the average man will be fully occupied.

Then he can afford neither the time nor money to keep posted on the conditions of the markets every day, or to become acquainted with the many intricacies incident to marketing.

An association, on the other hand, can afford many of these things, because of the volume of business involved. For instance, the manager must have daily telegraphic reports on the condition of the markets; he often has a personal acquaintance with the buyers, and he finds it to his advantage to make occasional trips for the purpose, even to distant states. He can also have a system of diverting cars after they have been sent out of the State and thus avoid a glutted market, or send his fruit where it will sell to better advantage than where it was first planned. The icing of the cars can also be properly looked after. Associations are often the means of getting lower freight rates, because the hauling of several hundred cars is an item worth competing for, and in a number of instances, the managers have been successful in getting rates changed to their advantage. Such rates are, of course, open to all shippers. Buyers often want a number of car loads of a certain variety and are willing to pay a premium if their wants can be supplied, and not infrequently such sales are the means of disposing of large amounts of the inferior varieties or grades. An individual is seldom in a position to take advantage of such opportunities. Associations are successful in maintaining a uniform pack, and by this means they establish a reputation for their goods. Usually the best grades of fruit are sold as a certain brand. The brand, which should be copyrighted, is sufficient guarantee for the quality, or, at least, it must be if the association expects to gain and hold a reputation.

Supplies of various kinds, which are used on fruit farms, may be bought at wholesale, often in car load lots, as indicated on Page 13, which is quite an advantage, especially in such items as spray and box materials. The saving which the association makes to the growers in this way is no small item, as everything is bought at wholesale. The prices to growers are only slightly in excess of actual cost. And then it is advantageous to keep a certain amount of the better class of help from year to year and to furnish them with employment, so a more or less extensive jobbing business may be carried on, as indicated on Page 13. It will be noticed that not only is a large amount of fruit growers' supplies handled, but a wholesale business in other lines may be done, depending upon the demands of the locality.

And, finally, an association can be handled more economically than it is possible for most individuals to market their fruit, unless they depend entirely upon the traveling buyer, or resort to the doubtful expedient of consigning to commission men.

Given a capable manager and a wise board of directors, there

can be but small chance of failure under our conditions. But men who are capable of handling 500 to 1,500 cars of fruit at a good profit are not common, and when one is found, every effort should be made to retain him. One of the first things that should be done for the manager, when a capable one is found, is to give him a salary in proportion to the amount of business done and the responsibility which must be carried. The latter item is certainly important when we consider that he may be responsible for a number of car loads of a very perishable product, which are on the road at once. Then, too much supervision on the part of the board of directors, who usually have small knowledge of the business, only hampers the manager and restricts his personality. If he cannot make a success of the association in his own way, the advice or help of the directors will be of little use. A much better plan is to give the manager a fair chance to work out his own ideas, and then if he fails, try another. But right here is the cause of most of the failures; too much supervision by the directors and unjust criticism and fault finding on the part of the stockholders.

A common source of discontent is the rumor that a neighbor in another association has received a higher price for his produce, or that an outside buyer is offering attractive prices. Unscrupulous firms frequently adopt the latter method of getting consignments only to swindle the grower. If there was not some decided advantage in buying direct from the growers, these firms would not go to the expense of maintaining an agent in the field when just as good or better fruit could be had from the association.

The association idea is no longer an experiment, and when each one does his share to maintain the reputation of the fruit, and the volume of business is sufficient to pay expenses, there is small chance of failure. The history of associations, the country over, shows that petty jealousies and distrust on the part of the members is the common cause of failure. One writer has summed up the subject in the following terse sentences:

"All classes of farmers are constitutionally and proverbially distrustful of other people and of one another. In a fruit association there arise (such is the experience) the most inveterate jealousies. Each man thinks he is furnishing a better grade of fruit than his neighbor, though all share alike in the profits. Each one fears the other will reap some special advantage somehow. In particular, the appointment of managers, superintendents, supervisors of grading, shipping agents, and all other officials of the company, offers a sufficient opportunity for the elaboration of all sorts of neighborhood quarrels. Each man thinks he ought to be manager, and when one man is finally chosen he is usually suspected of all sorts of favoritism. In any case he is apt to be hampered in his business relations by committees, boards of directors, and various kinds of red tape and foolishness. Often he has to consult a committee before taking any important action. * * *

"Another difficulty which arises from the same cause is that subscribers to such an association never want to pay a manager's wages. Two or three dollars a day is considered good pay. Yet such a man is com-

pelled at times to handle thousands of dollars' worth of business. The position is such as, in ordinary business life, would command a salary of five thousand dollars a year or more."—(Waugh; Fruit Harvesting, Storing, Marketing.)

Growers who are not members may ship through the association on the same terms, but they are usually required to pay more for supplies.

All of the larger concerns require both members and non-members, for whom they ship, to bring all their fruit to the association.

Formerly stockholders were allowed to sell their own fruit by paying the association a small premium. Neither were objections made to members filling orders from near-by towns. But, as these means of disposing of fruit are manifestly unfair to a majority of the association members, they have come to be looked upon with disfavor and in most instances are no longer allowed.

One of the strong points in favor of the association idea, as worked out in Colorado, is the possibility of a fairly uniform pack. This results in better prices, since buyers have the assurance that all associations strive to make their goods as nearly uniform as possible. Then, contrary to the idea often advanced that poor fruit brings as great a price as good, the most rigid grading must be practiced, and the intention is to place each fruit in its proper grade, thus only the best grade sells for the highest price, and, indeed, the grower of inferior fruit is fortunate to dispose of his crop at all.

There are two methods of packing and grading fruit; in one instance, the association does all the packing, the growers delivering the fruit to the packing house just as it is taken from the trees. Here the packers, under the direction of a superintendent, sort the fruit into the various grades, and at the same time pack it into boxes or crates. Should there be any culls, they are returned to the grower and are at his disposal.

Each grower is given a number, which is used to designate his fruit throughout the season. As each box is packed, it is marked with his number and the grade. When the boxes are loaded into the cars, the number of boxes, the varieties and the various grades which belong to any grower are kept account of and duly recorded. In this way the price for each box of fruit in any car is easily determined.

But where there is a very large amount of fruit to be handled it is impossible for the association to do the packing, consequently the growers assume this work. With this arrangement, the association employs an inspector, whose duty it is to inspect each load as it is delivered. This he does by opening the boxes on the side, in the case of apples, when a good estimate of the contents may be made. If the pack is satisfactory, not more than two boxes may be opened. If unsatisfactory, several may be examined, and if all

run under the inspector's standard, the entire load must either be placed in a lower grade or else be repacked.

It will be seen that a great deal depends on the inspector, and that it is a difficult position to fill. Upon him depends the reputation of the association, so he must be entirely free to do the work as he sees fit.

Each man's fruit is kept track of by numbers, as in the former case.

Most of the associations have now adopted the latter system, although nearly all have tried the former. The ideal method is, no doubt, to have all packing done at a central building, but a limit to the amount of fruit which can be handled is soon reached. It is found difficult in practice to keep track of a large number of packers at a central point, and careless work is the result. But when each grower looks after his own packing, he has a wholesome respect for the decision of the inspector. It is very expensive to repack a lot of fruit, and if he is obliged to do this, or else let it be sold as a lower grade, even on a single load, it usually results in greater pains being taken in the future. But with the best of systems, poorly packed fruit will occasionally find its way to market.

The association charges a commission on all sales, usually five per cent., to defray expenses. Then, in case the packing is done by the association, an additional charge is made to cover the cost of the box and packing. Any surplus is, of course, distributed as premiums. Any fruit grower may become a member of the association so long as there is stock for sale, and the owner of one share is entitled to all of its privileges. The number of shares one individual may own is limited.

The growers are generally asked and, in many instances, required to furnish an estimate of their crop. In the smaller associations, the manager sometimes secures this information by visiting the orchards in person. This estimate is made early in the fall, or not until damage by worms and other causes is practically over and the crop is secure. With this knowledge in hand, the manager can enter into contracts for delivering certain amounts of various varieties or grades.

The system of selling has been radically changed within the past few years. Formerly practically all of the fruit was consigned to commission men, who, as a class, it may be truthfully said, are inclined to do the best they can by their constituents. But too often the experience has been otherwise. Not infrequently has it happened that shipments consigned to a distant city have been reported as not being up to grade, or not in good condition, so the market price could not be realized. In such cases, though the manager may be certain that his fruit is as he represented, he is often unable

to help himself, so must take what he can get. But of late years, the plan of selling F. O. B. is being practiced more and more, and this is largely due to the organized efforts of the associations. Consignments are only made to well known firms, and much of this fruit is sold at auction.

But even with this arrangement difficulties arise, so in order to protect themselves, the larger associations have an agent at the more important distributing points. It is the duty of the agent, or broker, to inspect all cars which come into his territory, as near the destination as possible, and thus protect the association from dishonest buyers. He also is on hand to adjust the differences which arise when the fruit actually reaches the buyer in poor condition.

Express shipments are only made to comparatively near-by points, and with such shipments, the growers receive exactly what the fruit brings less the expressage and the association's commission. It is usually the early fruits that are expressed, but prohibitive rates prevent any very large amount of business being done in this way.

An association, well managed, is always a benefit to the entire community, in that it builds up a reputation for the fruit, and holds up prices, inasmuch as there is not that tendency, even among non-members, to bid one against another in marketing. This is well illustrated in the case of a prominent fruit grower who is a member of one of our successful associations. Because of superior ability as an orchardist and having a large orchard of choice varieties, he could easily get a price somewhat in excess of that which he receives through the association. But he realizes that it is the association which has built up and sustains the reputation of the locality, and should it fail, the chances are that local competition would again lower prices.

In addition to this, it may be said that the managers are constantly insisting on the necessity of growing better fruit, and so have been instrumental in introducing new and improved methods of culture and, in many instances, have been advance agents for the Experiment Station, and in this capacity have made our work pleasant, as well as acceptable, to the fruit growers.

The Northern District—By the Northern District is understood the territory which is adjacent to Denver and the country north along the foothills to Fort Collins. Associations are operating in most of these towns, but as small fruits are the principal crops handled, express shipments are the rule. The managers find that, usually, it does not pay to make F. O. B. sales of small fruits to the retail dealers, for the reason that such stores change hands frequently, consequently many bad debts result. This is the prin-

cipal difference in the management of the associations in the different sections.

The Boulder County Fruit Growers' Association at Boulder, has been the most successful. Its success is undoubtedly due to an efficient manager and a board of directors who have been content to let the manager handle the business.

With a much smaller volume of business and a much more perishable product, association management is more difficult than in many other localities. Yet the Boulder Association has not failed to make a good dividend on the stock every year since its organization. This is also one of the few which have branched out into other lines and have thus been enabled to do business throughout the year.

The examples cited are of successful institutions which have been in operation a sufficient length of time to thoroughly demonstrate the practibility of the system.

It must not be inferred, however, that other sections of the State have neglected to take advantage of the opportunities which combination in marketing affords.

Several associations in the Arkansas Valley have become prominent, but their management does not differ from that which has already been described.

The following list of fruit and produce and cantaloupe associations, which are now doing business in the State, will show what an important factor this method of selling horticultural produce has become:

LIST OF FRUIT AND PRODUCE AND CANTALOUPE ASSOCIATIONS NOW DOING BUSINESS IN THE STATE.

Amity Cantaloupe Growers' Association, Amity, Colo.
Bent County Melon Growers' Association, Las Animas, Colo.
Boulder County Fruit Growers' Association, Boulder, Colo.
Capitol Hill Melon Growers' Association, Rocky Ford, Colo.
Delta County Fruit Growers' Association, Delta, Colo.
Denver Fruit and Vegetable Association, Denver, Colo.
Fair Mount Melon Growers' Association, Swink, Colo.
Fremont County Fruit Growers' Association, Canon City, Colo.
Fruita Fruit and Produce Association. Fruita, Colo.
Fort Collins Fruit Growers' Association, Fort Collins, Colo.
Fowler Melon Growers' Association, Fowler, Colo.
Granada Melon Growers' Association, Granada, Colo.
Grand Junction Fruit Growers' Association, Grand Junction, Colo.
Branches at Clifton, Palisade and Whitewater.
Grand Valley Fruit & Produce Association, Grand Junction, Colo.
Independent Fruit Growers' Association, Grand Junction, Colo.
Kouns Party Cantaloupe Growers' Association, Rocky Ford, Colo.
Lamar Melon Growers' Association, Lamar, Colo.
La Junta Melon and Produce Co., La Junta, Colo.
Longmont Produce Exchange, Longmont, Colo.
Loveland Fruit Growers' Association, Loveland, Colo.
Manzanola Fruit Association, Manzanola, Colo.

Manzanola Orchard Association, Manzanola, Colo.
Newdale Melon Growers' Association, Swink, Colo.
North Fork Fruit Growers' Association, Paonia, Colo.
Palisade Fruit Growers' Association, Palisade, Colo.
Peach Growers' Association, Palisade, Colo.
Plateau and Debeque Fruit, Honey and Produce Ass'n, Debeque, Colo.
Rifle Fruit and Produce Association, Rifle, Colo.
Roaring Fork Potato Growers' Association, Carbondale, Colo.
Rocky Ford Melon Growers' Association, Rocky Ford, Colo.
San Juan Fruit and Produce Growers' Association, Durango, Colorado, and Farmington, New Mexico.
Surface Creek Fruit Growers' Association, Austin, Colo.
Woods Melon Growers' Association, Las Animas, Colo.

A STATE ORGANIZATION.

Now that local associations have become established institutions, there yet remains to be organized a combination of associations. A state association would perhaps not meet our wants so well as district organizations, since the fruit growing localities are widely separated and their conditions so diverse. It is true that the managers now work together to some extent, particularly on the Western Slope, but they all recognize that a much closer union would be desirable.

Not only would our fruit become better known and better prices result, but economy along many lines would be effected. If one man could have supervision of the sales of all associations, in a given section, the last trace of local competition would be done away with. The railroads, as well as the large dealers, could be dealt with to much better advantage by one man representing a group of associations than by a number of men representing the divided interest of several. Then, in the buying of supplies, one man could not only do the work more economically, but he would be able to get much better rates for the same reasons. The same line of argument would hold good for all phases of association management.

The time is not yet ripe, perhaps, for such an organization, but it is fast approaching. It is safe to say that the complete control of the market situation, to which the fruit growers of Colorado are entitled, will only be realized when such a combination is effected.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

The following report of the Grand Junction Association will assist in giving an insight into this form of successful co-operation. This Association has been chosen for the purpose of illustration, not because it is the most successful, but for the reason that it is the oldest and is doing the largest business of any in the State. This Association was started in 1891, when a few growers combined and appointed one of their number salesman of their fruit for

the season. This arrangement continued with varying degrees of success up to 1897, when it became apparent that the increased business, if no other cause, would necessitate employing a manager, by the year, who should devote his entire time to the association. Accordingly this was done, and the business has increased year by year, as shown below. That the majority of the stockholders are satisfied with the workings of the Association is proven by their loyalty and by the fact that the capital stock has recently been increased to $100,000, for the purpose of accommodating the increasing number of members.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

GROWTH OF BUSINESS.

Year.	Paid Growers.	Total Business.	Cars Shipped.
1897	$ 54,085.00	$ 88,937.00	167
1898	21,785.00	43,750.00	89
1899	21,346.00	56,591.00	82
1900	68,323.00	114,590.00	202
1901	98,972.90	153,380.00	256
1902	195,975.15	287,887.15	613
1903	247,188.45	339,305.41	682
1904	437,154.33	557,291.11	1,282
1905	475,763.00	608,403.30	797
1906	555,813.44	814,278.62	1,036

Number of stockholders January, 1907............ 666
Number of shares of stock sold to January, 1907....14,169

STATEMENT FOR SEASON 1906.

Fruit Shipments in Detail.

	Packages.	Amount.	Avg.
Extra Peaches	136,162		
Fancy Peaches	139,917	$207,936.19	.45
Choice Peaches	151,438		
Unwrapped Peaches	33,397		
Carrier Peaches	295	177.04	.60
Total	461,209	$208,113.23	
Fancy Pears	87,157	$100,104.49	1.15
Six Tier and Choice	31,425	20,712.42	.66
Half Boxes Pears	6,007	2,878.73	.48
Total	124,589	$123,695.64	
Fancy Apples	128,369	$129,054.14	1.01
Choice Apples	82,955	46,555.14	.56
Half Boxes	2,725	1,235.02	.45
Total	214,049	$176,844.30	
Crates Plums	16,857	$ 8,765.69	.52
Boxes Plums	8,096	1,896.02	.23
Total	24,953	$ 10,661.71	
Crates Grapes	8,382	$ 7,060.79	.84
Baskets Grapes	2,102	457.91	.22
Total	10,484	$ 7,518.70	
Crates Apricots	8,312	$ 5,263.96	.63
Boxes Tomatoes	3,887	1,395.13	.36
Boxes Crab Apples	322	126.54	.39
Jumbo & Stand Cants	13.087	12,219.21	.93
Pony Crates Cants	2,231	1,083.32	.49
Total	15,318	$ 13,302.53	
Crates Strawberries	1,199	$ 2,794.48	2.33
Crates Cherries	1,276	1,910.17	1.50
Cases Honey	1,652	4,187.05	2.54

Shipments of fruit for the season aggregate 867,250 packages, or 28,805,828 pounds, equal to 1,152 cars of 25,000 pounds each; 1,017 cars by freight, and the balance, equal to 135 cars, by express and local freight.

	Cars.
Amount of fruit shipped in car lots	1,017
Potatoes shipped in car lots	19
Total	1,036

Business of 1906.

Merchandise sales	$248,779.25
Fruit sales	565,499.37
Total	$814,278.62
Total amount paid to growers	$555,813.44

Cars Received.

	Cars.
Box shooks	123
Wrapping paper	6
Berry boxes and baskets	3
Spraying outfits	3
Nails	3
Bee supplies	1
Spray materials	22
Salt	7
Oranges and lemons	22
Nuts	2
Paper and paper bags	3
Hay	20
Grain sacks	1
Sweet potatoes	1
Cabbage	3
California potatoes	1
Manitou water	2
Beans	1
Total	224

Cars sent out	1,036
Cars received	224
Total cars in and out	1,260

Where the Fruit Went.

	Cars.
California	33
Colorado	146
Illinois	70
Indiana	1
Indian Territory	18
Iowa	76
Kansas	24
Louisiana	60
Maryland	12
Massachusetts	15
Mexico	3
Minnesota	59
Missouri	31
Nebraska	72
New York	76
North Dakota	1
Ohio	2
Oklahoma	15
Pennsylvania	28
Quebec	2
South Dakota	46
Texas	208
Tennessee	2
Utah	1
Wisconsin	12
Wyoming	4

BY-LAWS OF THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION

I.

The name of the said Association shall be the Grand Junction Fruit Growers' Association.

II.

The objects for which the said Association is created are to buy and sell fruit, vegetables, hogs, meat stock and all the products of Mesa County, both fresh and manufactured; to erect, operate and maintain canning and packing factories and commission houses; to manufacture any and all products of Mesa County; to lease, mortgage and sell said business, and to borrow money for carrying on the same, and to pledge their property and franchise for such purpose. To acquire by purchase, or otherwise, and own real estate, buildings, machinery and all the necessary power and power plants for carrying on said premises, and to lease, mortgage and sell the same.

III.

The term of existence of said Association shall be twenty years.

IV.

The capital stock of the said Association shall be twenty-five thousand dollars, divided into five thousand shares of five dollars each.

V.

The number of Directors of said Association shall be seven, and the names of those who shall manage the affairs of the Association for the first year of its existence are C. W. Steele, A. A. Miller, J. W. Rose, R. W. Shropshire, J. H. Smith, P. A. Rice and A. B. Hoyt.

VI.

The principal office of said Association shall be kept at Grand Junction in the said County, and the principal business of said Association shall be carried on in said County of Mesa.

VII.

The stock of said Association shall be non-assessable.

VIII.

The Directors shall have power to make such prudential By-Laws as they may deem proper for the management of the affairs of the Association not inconsistent with the laws of this State, for the purpose of carrying on all kinds of business within the objects and purposes of the Association.

BY-LAWS.

ARTICLE I.

Section 1. The Board of Directors provided for in the articles of incorporation of this Association, shall be elected annually at the regular annual meeting of the stockholders, as hereinafter provided, and shall hold their office until their successors are elected and qualified.

Section 2. Said Directors shall be stockholders in said Association and shall be fruit growers in Grand Valley and shall be residents of Mesa County Colorado.

Section 3. Any vacancy occurring in the Board of Directors shall be filled by the remaining members of the Board.

ARTICLE II.

Section 1. The Board of Directors shall, as soon as may be, after their election, elect a President and Vice-President from among their number, who shall hold their offices for one year, and at said meeting the said Board shall appoint a Secretary, Treasurer, and Manager, who shall be subject to removal at any time.

Section 2. The Secretary, Treasurer, and Manager, shall each, when required by the Board, give bond in such sum and with such security as the Directors may require, conditioned on the faithful performance of their duties, and to turn over to their successors in office all books, papers, vouchers, money, funds and property of whatsoever kind or nature belonging to the Association, upon the expiration of their respective terms of office, or upon their being removed therefrom, or with such other conditions as may be proper.

Section 3. The President shall preside at all meetings of the Directors or Stockholders. He shall sign as President all certificates of stock, and all other contracts and other instruments in writing, which may have been ordered by the Board of Directors.

Section 4. The Vice-President shall, in the absence of or disability of the President, perform his duties.

Section 5. The Manager shall have full charge of the commercial and shipping department of the Association. He shall receive all money arising from the sale of fruit and other commodities handled by the Association, and pay the same to the parties entitled thereto, and render a true account thereof; and he shall also be the Treasurer of this Association and safely keep all money belonging to the Association, and disburse the same under the direction of the Board of Directors, except as herein above set forth.

Section 6. The Secretary shall keep a record of the proceedings of the Board of Directors and also of the meetings of the Stockholders. He shall also keep a book of blank certificates of stock, fill up and countersign all certificates issued, and make the corresponding entries upon the marginal stub of each certificate issued. He shall keep a stock ledger in due form, showing the number of shares issued to and transferred by any stockholder and date of issuance and transfer. He shall have charge of the corporate seal and affix the same to all instruments requiring a seal. He shall keep in the manner prescribed by the Board of Directors, all accounts of the Association with its stockholders, in books provided for such purpose. He shall discharge such other duties as pertain to his office, and as may be prescribed by the Board of Directors.

Section 7. These By-Laws may be amended by the Board of Directors at any special meeting thereof called for that purpose, a notice of such proposed amendment being given in the call for such special meeting.

ARTICLE III.

Section 1. The regular meetings of the Board of Directors shall be held at the office of the Company, on the first (1st) day of each month, except when the first day comes on Sunday or legal holiday, then on the following day.

Special meetings of the Board of Directors may be called by the President when he may deem it expedient or necessary, or by the Secretary, upon the request of any three membrs of said Board.

Section 2. A majority of the Board of Directors shall constitute a quorum for the transaction of business, but a less number may adjourn from day to day upon giving notice to absent members of the said Board, of such adjournment.

Section 3. The Board of directors shall have power:

First—To call special meetings of the stockholders whenever they deem it necessary, by publishing a notice of such meeting once a week for two weeks next preceding such meeting in some newspaper published in Grand Junction, Colorado.

Second—To appoint and remove at pleasure all employes and agents of the Association, prescribe their duties, where the same have not been prescribed by the By-Laws of the Association, fix their compensation, and when they deem it necessary, to require security for the faithful performance of their respective duties.

Third—To make such rules and regulations not inconsistent with the laws of the State of Colorado, and Articles of Incorporation, or the By-Laws of the Association, for the guidance of the officers and the management of the affairs of the Association.

Fourth—To incur such indebtedness as they may deem necessary for carrying out the objects and purposes of the Association, and to authorize the President and Secretary to make the note of the Association, with which to raise money to pay such indebtedness.

Section 4. It shall be the duty of the Board of Directors:

First—To be caused to be kept a complete record of all their meetings and acts, and also the proceedings of the stockholders, present full statements at the regular annual meetings of the stockholders, showing in detail the assets and liabilities of the Association, and the condition of its affairs in general.

Second—To supervise all acts of the officers and employes, require the Secretary, Treasurer and Manager to keep full and accurate books of account of their respective business.

ARTICLE IV.

Section 1. At the regular meeting in the month of January of each year, the Directors shall declare such dividends upon the capital stock, to all the stockholders then appearing of record, as may be warranted by the net earnings of the Association for the preceding year.

ARTICLE V.

Section 1. The Board of Directors may, whenever they shall deem it necessary, place on sale so much of the capital stock of the Association as may be necessary to raise funds, for the purpose of carrying out the objects and purposes of the organization of the Association, such stock to be sold only upon the following conditions:

First—That not more than three hundred (300) shares thereof be sold to any one person, firm or association of persons.

Second—That such stock be sold only to fruit growers in Grand Valley.

Third—That such stock be sold at not less than par value of Five Dollars ($5) per share.

ARTICLE VI.

Section 1. The Annual meeting of the stockholders for the election of Directors, shall be held on the third (3rd) Saturday in January of each year, but if, for any reason, it should not be held on such day, it may then be held on any day subsequent thereto, as hereinafter provided.

Section 2. The Board of Directors shall be elected by the stockholders at the regular Annual meeting. Public notice of the time and place of holding such annual meeting and election, shall be published not less than ten (10) days previous thereto, in some newspaper of general circulation printed in Grand Junction, and the said election shall be made by such of the stockholders as shall attend for that purpose, either in person of by proxy, provided a majority of the outstanding stock is represented. If a majority of the outstanding stock shall not be represented, such meeting may be adjourned by the stockholders present for a period not exceeding sixty (60) days. All elections shall be by ballot, and each stockholder shall be entitled to as many votes as he or she owns shares of stock in said Association; provided, however, that no person who is not himself a stockholder shall be allowed to represent by proxy any stock-

holder in the said Association.

The persons receiving the greatest number of votes shall be the Directors for the ensuing year, and until their successors are elected and qualified.

ARTICLE VII.

Section 1. Certificates of stock may be transferred at any time by the holders thereof, or by attorney in fact or legal representative. Such transfer shall be made by endorsement on the certificate of stock and surrender of the same; provided, such transfer shall not be valid until the same shall have been noted in the proper form on the books of the Association. The surrendered certificates shall be cancelled before a new certificate in lieu thereof shall be issued, and no transfer of any share of stock shall be valid or allowed upon the books of the Association upon which any deferred payments are due and unpaid, nor which has not been sold and transferred in accordance with the provisions of the By-Laws of the Association.

Section 2. Any stockholder desiring to dispose of his stock in said Association, shall deposit the same with the Secretary of the Association, and the same shall be sold by the said Secretary at not less than par for account of such stockholder, within sixty (60) days from date of such deposit, under the restriction of Section 1, Article 5, of these By-Laws; provided, that if the Secretary shall not have sold such stock at the expiration of sixty days, then such stock may be returned to such stockholder, and be disposed of by him, without restriction or limitation by the Association.

ARTICLE VIII.

Section 1. All members of this Association are required to market all their fruit through the Association and bear their proportionate share of the expenses of handling the same.

Section 2. Any member may have the privilege of selling his own fruit at the orchard, but no sales of fruit shall be made to a dealer in fruit, or to any person who buys to ship outside the county. In case of the sale of the entire crop of any particular fruit or fruits, by reporting the same to the Association, one-half (½) only of the regular commission will be charged.

Section 3. Any member having any grievance or cause of complaint as to treatment of his fruit by the Association, can appeal to the Board of Directors, whose decision shall be final.

Section 4. All members must pack their fruit for shipping in a neat and workman-like manner, and pack the same in standard sized packages, as adopted and in general use by the Association, having placed thereon their name or number.

ARTICLE IX.

Section 1. A purchaser of stock in this, the Grand Junction Fruit Growers' Association, shall hereafter receive of the profits of the Association, in proportion to the money he has invested.

GRADING LIST OF THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

Peaches.

Boxes containing 80 peaches or less.................................Extra
Boxes containing 81 peaches to 94...................................90's
Boxes containing 95 peaches to 108..................................108's

All grades must be free from worms and other defects.

Fancy Apples.

Winesap, Grimes Golden, Missouri Pippin, Red Romanite, Geniton, and kindred varieties, must be two and one-fourth (2¼) inches in diameter and up. Jonathan, Arkansas Black, Ben Davis, Gano, Willow Twig, Shackelford, Pearmain, Mammoth Black Twig, Rome Beauty, W .W. Pippin, Mann, Talman Sweet, Dominie, McIntosh, Wealthy, Steele's Red, Lawver, Baldwin, Huntsman, Spy, Minkler, Stark, Smith Cider, Walbridge, Pewaukee, York Imperial, etc., two and one-half (2½) inches in diameter and up. absolutely free from worms and other defects, bright and normal color, and shapely in form.

Choice.

Shall not be less than two and one-fourth (2¼) inches in diameter and reasonably free from worms, in other words, only stock a little below fancy. Throw away your trash, it won't pay freight. We also advise using the diamond pack.

The above rules for sizes do not apply to early summer varieties of apples; we will only ship one grade—Fancy.

Fancy Pears.

Must be free from worms, smooth and of good shape; gross weight, 53 pounds of more. The number of tiers must be stamped on the box.

Choice.

Reasonably free from worms; in other words, only a little below Fancy.

Plums—Prunes.

The large fancy Hungarian, Italian, Botan, Green Gage, Egg, etc., are put up in four basket crates, well filled, net weight 20 pounds, or more. Small varieties, Wild Goose, Mariana, Damson, and the smaller plums of all varieties, in two and one-half (2½) inch boxes, well-filled, net weight 16 pounds, or more.

Grapes.

Concords in 8-lb Climax baskets, and should be well-filled. Muscat, Rose Peru, Tokay, Purple Damascus, Black Hamburg, in four basket crates, same as California, and must weigh 28 pounds or more gross. See rule for packing grapes.

Cantaloupes.

Both standard and pony crates must contain 45 melons and be tight in the crate.

PUT YOUR NUMBER, VARIETY, AND GRADE ON THE UPPER LEFT HAND CORNER OF THE BLANK END OF THE BOX.

Any one who does not know when to pick fruit, or how to pack it, should consult with our Inspector, or their neighbors.

To Dealers.

In ordering peaches by wire or letter, the different grades will be known as Extra, Fancy and Choice. We guarantee our pack to grade as above, and in case they do not, please advise us, giving stencil number.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

Bulletin 123 January, 1908

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

THE PLAINS

SOME PRESS BULLETINS

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

*After March 1, 1908.

THE PLAINS

PRESS BULLETINS

This bulletin is made up of a number of press bulletins relating to the Plains, and giving advice to Plains settlers. They have been reprinted under this form for convenience. They consist of:

ADVICE TO PLAINS SETTLERS.

BY J. E. PAYNE.*

We recognize it as a fact that many new settlers have taken up residence in the Plains region during the last few months who have merely enough capital to put up houses, break a few acres of sod, and live during the first six months.

The people cannot wait for results promised by the exploiters of "Scientific Soil Culture." They must have results this season. It is to this class of people that we would address the following suggestions:

First. If you have a milch cow give her the best care possible, and get as many more as you can. Sell cream, or make good butter or cheese. Sod cowhouses are within the reach of all who can work.

Second. Keep as many hens as you can take care of. Feed well and protect from coyotes and other beasts of prey. If you can raise turkeys and geese they will pay. Turkeys and geese may be herded by children, and turkeys are the best grasshopper exterminators known.

Third. For field crops on sod, plant early amber cane, yellow Milo maize and corn. The seed used should be grown in the vicinity if possible, if not, choose some early variety. If you are able to do so, prepare a small field for fall wheat.

Fourth. Plant a garden. If you have no well, plant a small plat near the house and water it with the waste water. Bury every drop of waste water beside some vegetable by making a furrow beside the plants and after the water has sunk away fill the furrow with dry dirt. Old tin cans sunk in the ground by the side of hills of cucumbers aid in watering them economically. Punch holes in the bottoms of the cans.

If you have a well, plant a large garden but plant all garden stuff in rows so that it may be cultivated with horse power. Use the water with the same economy that you would if using only waste water. Never flood the ground purposely. If any should be flooded, stir it thoroughly as soon as it is dry enough.

It is a common mistake with beginners in irrigation to try to make water take the place of cultivation. The result is failure. Another

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*The writer has fought grasshoppers and drought in Eastern Colorado for many years. Besides early training in Kansas, he was in charge of work on the Plains for the Colorado Experiment Station from 1896 to 1904, as Superintendent of the Sub-station at Cheyenne Wells, and as Field Agent for the Experiment Station. Is now in the employ of the U. S. Department of Agriculture in the Dry Land Division, to be located at Akron, Colo.

common mistake is to plant a larger area than can be watered from the well. Better begin with only a few square rods and extend the area as experience dictates.

In case you cannot irrigate from a well, select a small patch of ground upon which you can turn the flood water from the prairie by means of furrows. If you can make a small reservoir above the patch, do it. The reservoir may hold a few barrels of water until you have time to direct it to the plants which need it. Cultivate thoroughly and keep all weeds down.

Besides the small truck, a good patch should be planted to Mexican beans, early cow peas, watermelons, muskmelons, stock melons, pumpkins, squashes, popcorn, sweetcorn and potatoes. These will sometimes bring good crops without irrigation. Enough should be planted so that a plentiful supply of winter food for the family will be assured. Stock melons are very productive, and if stored in sod buildings, above ground, they will furnish green food for the milch cows during winter. I have grown stock melons at the rate of 20 tons per acre. I have kept ordinary watermelons until the last of November by packing them in hay and storing them in a room where they kept cool but did not freeze. There are varieties of winter watermelons and muskmelons which are good from Christmas until March.

By planting the following seven varieties of sweetcorn on the same day—and often near the last of May—I have had roasting ears from July 26th until September 26th. The varieties were: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentleman, Mammoth Evergreen, and Egyptian. The large varieties may be dried for winter use or allowed to ripen to be used parched. Parched sweetcorn is a luxury, but one which is within the reach of the poorest settler. White Pearl and Queen's Golden popcorn have done well for me, and my family have had many meals consisting only of whipped cream and popcorn.

Potatoes, squashes and pumpkins may be grown successfully by keeping up a constantly successful fight against potato beetles and squash bugs. This means to battle almost daily with the pests from the time the potatoes are up until the middle of August, and from the time the squash plants are up until the squashes are ripe. To describe methods of fighting these pests would require volumes, but we advise you to use your ingenuity in killing them. I preferred to kill them with clubs.

Grasshoppers are the worst enemies to field crops, but by keeping plenty of poultry, the grasshoppers will be kept down.

To produce crops of any kind may require an amount of labor which seems enormously out of proportion to the market value of the produce, but we assume that people who have settled here desire to build up homes and they have come here because they failed to get homes elsewhere. It may be a comforting thing to remember that you may not be working any harder here while trying to establish independence than you would be if working by the day for some one for just enough wages to support yourselves.

CROPS FOR UNIRRIGATED LAND.

BY J. E. PAYNE.

After seven years of experience in Eastern Colorado we feel justified in making some recommendations for the use of those who may try crop raising there without irrigation.

Soils. We have never seen any good crops grown without irrigation upon adobe or very heavy clay soils. But upon sandy loam, sandy and medium and light clay soils, we have seen crops raised on a paying basis nearly every year when given especial attention.

Seeding and Culture. The natural vegetation of the country shows that thin seeding is necessary. The buffalo grasses are thin where they do not get the use of the rain which falls, and thick in locations which catch extra water, as in low lands partly surrounded by hills. All crops should be planted thinly, so that they will not need too much water to make the growth high enough to harvest. All crops should be thoroughly cultivated, so as to give them the benefit of the largest per cent of the rainfall. Thorough and clean culture should be pursued until August 1st, whether rain falls or not, as the crop is thus kept in good condition to use rains which fall late in the season; while if the crops are not kept clean, no amount of cultivation after the late rains will take the place of the cultivation which should have been given before. The most important thing—next to water—is doing the work at the proper time.

Ground intended for planting in May should be thoroughly disced in March or early in April so as to hold the early moisture.

These remarks refer only to crops which are recommended in this bulletin, and to crops usually planted in rows and cultivated.

Crops to Depend Upon. Eastern Colorado is mainly a stock country, and the needs of the country demand rough forage for wintering stock.

We have found that the sorghums and a few acclimated varieties of corn produce paying crops, taking an average of five year's crops as a basis for estimates. Very few of the sorghums ripen seed in Northeastern Colorado, so if one wishes to produce seed of either *corn* or *sorghum,* he should be careful to plant seed which was grown in the vicinity .

The following table gives the most important facts concerning the varieties best known.

Name.	Sweet or Non-Saccharine.	Produces Seed.	Fodder.	
			Quality.	Quantity.
Early Amber	Sweet	Abundantly	Good	Large
Early Orange	"	Sparingly	"	"
Kansas Orange	"	"	"	"
Colman	"	"	"	Medium
Collier	"	"	"	"
Folger's Early	"	"	"	"
Red Kaffir Corn	Non.-Sac.	"	"	"
White Kaffir Corn	"	"	"	"
Jerusalem	"	Abundantly	Poor	Small
Yellow Milo Maize	"	Sparingly	Good	Medium
White Milo Maize	"	"	"	"
Brown Durra	"	Abundantly	Poor	Small

Broom Corn. Broom corn is usually easily raised. The market price of good brush makes its production profitable or unprofitable and not the amount which can be produced. The fodder and corn always have a ready home market, but broom corn must be sent out of the country.

Mexican Corn. A flint variety grown in Northern Lincoln, Western Kit Carson, and Central Arapahoe counties. Very rich in protein. Some years the ears merely stick out of the ground and the tassels may not be more than two feet high.

There are several other varieties of corn which do well, but they are confined to small neighborhoods and we cannot be sure that much seed could be had.

Planting. Planting should be done with a lister drill. Use from two to five pounds of seed per acre—according to quality of seed.

Cultivation. This should be done as long as possible with the harrow. Then follow with the weeder, and if it seems best, with the cultivator. *Careful* and *thorough* culture must be given. If planted on sod, it may be planted by a special planter drill. If planted on land broken years ago and left unused during recent years, it will not be likely to produce a good crop unless the season is very favorable.

Time of Planting. May 1st to June 10th, according to the conditions. Sorghum does not grow much until warm weather, but it should be planted while the early moisture is in the ground.

With up-to-date tools and plenty of horses one man can plant and cultivate 160 acres in corn or sorghum. He must use gang listers, large harrows and gang weeders in order to do this, but by working in this way the cost of producing feed may be reduced considerably.

The sorghums are as sure to make a paying crop in Eastern Colorado as corn is in Eastern Kansas.

It is the hope of the author that he can help the people to make two steers grow in Eastern Colorado "where one grew before."

DAIRY WORK FOR PLAINS SETTLERS.

H. M. COTTRELL.

Thousands of families are coming to Colorado this spring to locate on farms. Many of them are locating in the dry land sections of the state, often on land on which a furrow has never been turned.

The methods of handling the soil, the varieties of seeds used and the handling of the crops after seeding are entirely different from those found profitable in Eastern States. Experienced men who have farmed in two or more states and under widely different conditions do not expect to meet expenses for crop raising the first year while they are learning what methods and varieties are most profitable in a new location.

Many of our new settlers have a limited amount of capital, and a failure of crops this year would bring suffering to a large number and financial hardship to others.

To those settlers whose means are not sufficient to carry them through a year of crop failure and have sufficient left to grow a crop the second year, we would advise the breaking up of a small area only, not over 40 acres on a quarter section, and if money is quite limited, not over 20 acres .

Write to the Experiment Station, Fort Collins, Colorado, for advice as to the best methods of preparing the soil, the best crops to plant varieties to use and the best method of treating the crops after seeding. This advice will be given gladly and freely.

The new settler should consult the successful farmers who are his neighbors, asking them the same questions that he asks the Experiment Station. Then utlizing the advice from his neighbors and the Station, handle his 20 or 40 acres in such a way as to get the largest yield from them. He will learn more from cultivating this small area well than he will if he puts all the land he can into crops and is obliged to do the work poorly.

While learning how to raise profitable crops under his new conditions, the farmer will need an income to support his family. One of the best ways of securing this is by milkng cows and selling the cream to a factory.

Range cows selected for milking qualities and fed on the native prairie pastures of Colorado alone will produce through the summer from $2 to $5 worth of milk per head a month. All the creameries pay cash at least once a month, and some of them pay daily. The farmer, if he cultivates a small area only, will have the help to milk from 10 to 15 cows, and these will give him a cash income of from $20 to $75 a month, depending on the number and quality of the cows milked.

Selling the cream to the creamery will require much less outlay for building and equipment than will be needed if butter is made on the farm, and will make the work much lighter for the housewife,

whose work is already hard enough when starting in a new home.

The calves should be sold for veal as soon as old enough, and the work saved in not raising them by hand can be put on the crops and in making improveemnts.

The warm separator milk can be fed at a good profit to pigs and poultry, giving another source of cash income to the new settler.

Sorghum should be sown broadcast to be fed in the fall to keep up the flow of milk.

In selecting range cows for dairy work the grade short-horn has been usually found the most satisfactory. The cow should be selected for four dairy points—a good udder, prominent hip bones, a sharp bone at the top of the shoulder and large stomach capacity. The writer selected a carload of range cows along these lines: None of them had been fed grain and several had to be roped before they could be milked. These cows averaged over $40 per head the first year in cream sold to the creamery, and one cow with these points well developed produced $60 worth of cream the first year.

PREPARATION OF SEED BED.

HINTS FOR THE PLAINS.

BY W. H. OLIN.

Crop conditions in Eastern Colorado are so different from crop conditions in the humid region that special attention should be called to them for the benefit of the new settler.

The very best system of tillage may fail to produce a crop some years, but proper soil management and use of acclimated seed adapted to prevailing conditions tend to render crop failures less frequent and harvests therefore more remunerative.

In the farming operations of many parts of Eastern Colorado, where irrigation can not be practiced, the amount of water available to plants is the "limiting condition of success," as Prof. Failyer calls it. Here is found abundance of cheap land, quite fertile, and water is the element that must be most carefully conserved to insure a crop. No rain water must be allowed to run to waste if possible to store it in the soil. Rains on the plains are usually quick dashing rains and the seed should be in such tilth that both upper soil and subsoil will readily absorb the water which falls during the crop season.

The preparation of the seed bed calls for careful plowing, harrowing and sub-surface packing.

Experience demonstrates that the preparation of the soil reservoir (seed bed) of good depth several months before seeding, the thorough culture of the ground before and after seeding, are essentials that very largely determine success in Eastern Colorado. Summer tillage conserves moisture while it renders more plant food available, keeps down weeds, and keeps the soil in good tilth.

Preparing New Ground for Spring Seeding.—It is always a questionable practice to crop newly broken sod in a dry year. The sod usually contains but little moisture and the process of breaking causes one to lose an appreciable portion of it. Suggestive plan: Plow sod land not less than three nor more than five inches deep, turning sod down as flat as possible, and thus prevent its drying out too soon. Follow as closely with disc harrow as practicable, and this with some form of packer, either single or double roll. This will level the sod land above, and firm the soil in the lower portion of the furrow slice, restoring the capillarity where plowing has arrested it. This firmed under-surface soil is thus enabled to draw moisture from below and give good, normal root development. Follow up the packer with either an acme or a good smoothing harrow to produce a good earth mulch to arrest surface capillarity and check evaporation of soil moisture. Follow with the seeder. All small grain should be drilled in with a press wheel drill, followed up with a good spike-toothed or smoothing harrow. It is almost necessary that all tillage operations on sod be with the furrows rather than across them to avoid tearing up the sod and drying out your seed bed. Do not seed broadcast. Make each tillage operation thorough—plowing, disking, firming, harrowing, and seeding.

When the new crop is up, cross harrow to prevent the formation of a crust and giving the young crop a cultivation. Follow up each rain with a good harrowing as long as character of crop will permit.

Early in June prepare seed bed for the fall and following spring's seeding. Try to hereafter seed only on ground which has been given "summer culture" treatment.

Remember that roots of all cultivated crops make their best growth when you provide:

A firm mellow
A warm mellow
A ventilated
A moist
} Soil well supplied with plant food.

Methods of farming which (a) conserve the moisture, (b) prepare a good seed bed, (c) reduce the evaporation to as near the minimum as possible, (d) use good vital acclimated seed, (e) employ a crop rotation which has stock foods prominent, contain at least one money crop, (f) and practice thorough tillage of the ground, often tide the farmer over bad years and insure his success in good years.

SUMMER CULTURE TO CONSERVE MOISTURE.

HINTS FOR PLAINS SETTLERS.

BY W. H. OLIN.

Many hundred farmers, unfamiliar with the soil and climatic conditions of our eastern plains, are this year coming to make homes

on 160-acre farms in Eastern Colorado in regions where crops have not been generally grown. Many of these settlers have but a limited amount of money and can not afford a crop failure. It is feared that this spring crop will be only partially successful, since many of them are farming as they did "back home," and are not using drouth-resistant crops of demonstrated value in their farming operations. This timely suggestion is sent out to prevent crop failure in fall seeding. Preparation of seed bed is the most important thing in farming the non-irrigated lands, and as soon as spring crops are in, the new settler should plow and cultivate his field he expects to seed to fall crops, or the following spring's grain.

Summer culture is an essential of the Eastern Colorado farmer's success. The French found some centuries ago that "manoeuvering" the land—causing the particles of earth to change place by tillage—made it more productive. Experiments now show that summer tillage in our semi-arid lands has an added value—it conserves the moisture, while it renders more plant food available. Good results have been obtained in Eastern Washington, Eastern Oregon, Utah, and many sections of Colorado from summer culture of the land every other season. It has been found that in this way sufficient moisture can be stored from the year's rainfall to mature a crop in many localities.

After the snows of winter have melted in the spring, plow the ground at least seven or eight inches deep. With disc harrow, corrugated roller, imperial pulverizer, or packer, level and firm this ground as soon after plowing as possible, at least not later than each half day, and follow up with smoothing harrow to establish the earth mulch to check evaporation. This mulch must not be too fine, as the winds of the plains will tend to rift the soil or blow the earth mulch entirely away. If possible, stir the surface soil with a good spike-tooth or acme harrow several times through the summer from two to four inches deep. Follow every summer rain with a good harrowing of this "summer cultured" ground, preventing the formation of a crust at the surface. Keep this ground clean—free from weeds.

Ground that has been well cultivated for several years will produce two crops in succession and can be given summer culture the third year. In this way it is possible to grow two crops in three years on well-tilled soil. If a farmer expects to cultivate 80 acres, he should divide it into two crop divisions—cropping 40 acres the first year and giving summer culture to the other 40 acres. This gives him a crop on one half his land each year while he is storing up moisture in the soil reservoir of the other half to make the next year's crop. A farmer on the non-irrigated lands in Weld County last season, after seedng his spring crop, at once prepared his fall wheat seed bed—150 acres. The writer visited his field early in July and found his seed bed in a fine mellow, moist, condition for seeding. Just a few miles from this careful farmer's ranch was a 500-acre field which had been simply plowed and left in that condition to dry out and become hard. Although an inch of rain had fallen the week previous, the writer found the soil in this field in very poor mechanical condition—dry and hard.

This clearly shows how not to do. Farmer No. 1 now has a most promising field of wheat and will undoubtedly be rewarded with a satisfactory harvest.

One of the writer's correspondents, living ten miles south of Akron, Colo., has practiced summer culture for several years. He reports that in the fall, when he seeds his summer cultured land, he often finds from three to five feet of moisture.

The writer knows that this method of summer culture has been practiced in some parts of California for upwards of forty years with satisfactory results.

Use every practical method you can to conserve the moisture. Summer culture keeps the ground in good tilth, keeps down weeds, renders the plant food easily available for the next year's crop, while it stores up the moisture so necessary to the plant in assimilating its food.

ACCLIMATED SEEDS.

HINTS FOR NEW SETTLERS IN EASTERN COLORADO

BY W. H. OLIN.

So many settlers, coming from the humid regions of the central states into Eastern Colorado this spring, are bringing with them the seeds of the crops grown "back home," with which they hope to grow crops in a much drier region, that a word of caution is neccessary.

Difference in altitude, amount of rainfall and general climatic conditions urges the writer to warn the new settler that past experience has shown that it will be hazardous to use any but acclimated seeds of such types of grain, forage and root crops as successful farmers of that locality have demonstrated show fairly good drouth resistant power.

Even with the most vital seed of established worth, in some seasons, lack of timely rains jeopardizes a profitable harvest. Last season one Eastern Colorado farmer seeded a drouth resistant strain of wheat, getting twenty-five bushels of good, sound wheat, and in an adjoining field, with the same seed bed preparation and after treatment, he seeded a wheat from another state of unknown drouth resistant power and got seven bushels per acre of inferior quality.

This is further illustrated in every crop grown on the eastern plains of Colorado. Seed, if you will, your choice imported grain in a seed block of an acre or less, but be sure to secure for the general field, grain that is acclmated to semi-arid conditions. The following crops have proven to be reasonably certain in average years for this region:

GRAIN.

Corn.—(An early maturing corn should always be used)
White Australian Flint.
Swadley Dent, and
"Divide" Dent, or Colorado Yellow Dent.

Wheat.—For Spring—
Kubanka Durum.
For fall seeding—
Turkey Red, or
Kharkov.

Barley.—(A bald barley or beardless type, seeded early.)

Rye.—One of the surest crops for hay or grain.

Oats.—This is not a reliable crop every year, but early types, as the Big Four, Kherson, and Sixty Day, acclimated to that region, have given very good harvest for several seasons.

Flax.—This is a new crop to Colorado, and for two years has done well, but its worth has not yet been fully proven. The writer would urge settlers not to seed this crop extensively until it has been more fully tested. If this seed is used, be sure to treat seed with formalin before seeding. The writer will send directions on request. Get Colorado-grown seed, if possible.

Emmer.—(Commonly called speltz.)—A drouth-resistant feed grain.

FORAGE.

Kaffir Corn, Dwarf Milo Maize,
Early Amber Sorghum, and
Proso, are good forage crops.

ROOTS.

Potatoes, where non-irrigated, or "Divide" seed is used, have proven the best root crop in recent years for the plains region.

Seek to grow that crop which will furnish feed, and plan to make some form of meat production the main product of the farm. Get the seed of a few well-tried crops and plan to seed them early, so the crop may get what early spring rains may chance to fall.

Rate of seeding is very important, since seeding too heavily takes up the limited amount of moisture in the ground, causing the whole crop to "fire-burn." Do not seed as heavy as you did in the central or eastern states. The following table may be suggestive, but rate of seeding will vary with manner of seeding, size of seed and condition of seed bed, so no definite rule can be laid down. Do not seed broadcast, if you can possibly drill in the grain.

Rate of Seeding for Eastern Plains.

Grain Crops.	lbs. per acre.
Wheat	30 to 50.
Wheat (Kubanka Durum)	40 to 50.
Barley	35 to 50.
Oats	35 to 50.
Rye	30 to 40.
Emmer or Speltz	35 to 50.
Field Peas	25 to 40.
Proso	6 to 12.
Forage Crops.	
Sorghum	8 to 20.
(Varies with the method of seeding.)	
Alfalfa	15 to 25.
Meadow Fescue	15 to 25.
Brome Grass	15 to 25.
Vetches	18 to 30.

POTATOES ON THE PLAINS.

BY E. R. BENNETT.

Where potatoes can be grown in this State they have proven one of the most valuable of the farm crops. However, little investigation has so far been made of the methods of culture that are best adapted to the conditions under which potatoes must be grown on the unirrigated lands of Eastern Colorado. Some very good crops of potatoes have been grown in this section in the past year or two, and it is thought possible that considerable acreage may be planted this year.

The methods of growing employed and the best varieties to plant are necessarily different from those used in the irrigated districts, so a word of advice to the new comers may be timely.

While it is advisable for every farmer to plant potatoes enough for the use of the family, we would not advise those inexperienced in the business to plant a large acreage at first. An acre or two, if successful, will more than supply the family needs, and, if unsuccessful, comparatively little will be lost.

Varieties and Seed.—One of the first requisites for success in growing potatoes on the plains is to get seed that is adapted to the conditions. Probably the best is that which has grown under similar conditions for several generations. If that is not to be had, seed from the Arkansas divide (Elizabeth)country, or even from Dakota, Minnesota, or Wisconsin will do. Seed from the irrigated lands should not be used.

Usually the early part of the season suffers less from drought than the latter; therefore, the early maturing varieties are generally better for the purpose than the larger late potatoes. Early Ohio and Rose Seedling have been grown in this State with considerable success in the past and are probably safer to use than some of the common Eastern varieties.

Soils.—Potatoes are grown on nearly all kinds of soils, but the lighter soils that will hold moisture are generally to be preferred. Land that has been cultivated should be selected in preferance to raw land.

Preparation of the Land.—Plow the land to a good depth when in good condition to work as early in the spring as possible. Harrow the land as fast as plowed to form a soil mulch and prevent loss of moisture by evaporation. From the time plowing is done till planting time, the land should be frequently harrowed. If rains come, the land should be harrowed as soon after the rain as the land can be worked without puddling the soil.

Planting.—In most cases the earlier the planting can be done without danger of early frosts hurting the vines, the better. When it is possible to do so, use a machine for planting, for by so doing

the seed is put down into moist soil, while hand work is apt to leave seed covered with loose, dry soil, in which case the seed will be delayed in coming up and a poor stand result. If the seed is planted deep (not less than five or six inches), this trouble will be to a certain extent avoided. If machines for planting are not available, the hand potato planter used in the East will do the work fairly well.

With the limited amount of moisture that is available for the crop, the plants will do better if planted at a greater distance apart than is usually practiced. If the hand planter is to be used. the field can be marked out as for corn and planted in rows both ways. If the machine is used, rows from forty inches to four feet apart with hills twenty inches to two feet apart in the row will probably give the best results.

Cultivation.—After the potatoes are planted, the success or failure of the crop will, to a large extent, depend upon the cultivation given.

The first cultivation should be given soon after the potatoes are planted, before the plants are out of the ground. Set the cultivator to run as deeply as possible to loosen and aerate the soil. The cultivator should be immediately followed by the harrow to smooth the surface and re-establish the soil mulch. After the potatoes are up, frequent shallow cultivation should be given till the vines become too large to work.

WIND-BREAKS AND SHELTER BELTS FOR THE PLAINS

BY B. O. LONGYEAR.

Wind breaks, as the term implies, are plantations of trees or similar plants intended to check the force of the wind. They may be used to lessen the drying effects of hot winds in summer to prevent injury or loss to fruit in autumn, and to shut off the cold winds of winter from yards and buildings. Wind-breaks for the last purpose are usually called shelter belts, and are often made several rods in width.

The location of the wind-break will, of course, depend on the direction of the prevailing winds. For general purposes the north and west sides of the area to be protected are the ones along which the trees are planted in most portions of this state. Shelter belts should be planted far enough from buildings so that drifting snows on the inner side will not be an inconvenience.

The simplest kind of wind-break is one formed by planting some one species of tree in a single row. If a tall-growing tree is used alone in this way there is a tendency for the trees to spindle up and in time the trunks lose their lower branches. Such an arrangement may do very well for a time, or where only partial checking of the wind's force is desired. But where more complete shelter

from winds is desired, it is usually necessary to plant several rows of different species, so arranged that the low, dense-growing kinds will fill in the places between the taller ones.

For the taller-growing tree in this region the common cottonwood may be used, setting them about eight feet apart for the outer or north and west rows. A second row of some denser-growing kind should be planted about eight feet from the first and as close as four feet in the row. For this purpose box elder is a suitable tree, except in dry situations, in which case the green ash is recommended. The trees in the third row may be planted the same as in the second row, using a more compact-growing kind. The Russian golden willow is recommended for this purpose as a rapid grower. The Russian wild olive is a more compact tree of lower growth and is particularly desirable. White or American elm is also a suitable tree for the inner rows in many places, especially where a fair amount of moisture can be depended on.

In cases where the wind is exceptionally strong, it may be found necessary to plant a belt four or five rods wide, in order to secure complete protection. The outer two rows may consist of Russian olive, the third and fourth rows of black locust, the fifth and sixth rows of box elder or ash, the seventh and eighth rows of American elm, and the inner two or three rows of cottonwood or Carolina poplar, the rows being about eight feet apart. The golden Russian willow may be used in place of the elm, and honey locust may take the place of the black locust.

The ground should be prepared as carefully as for a crop of grain or sugar beets. Where the rows are to stand, the soil should be furrowed out each way by making a back furrow between each two rows. When harrowed, the land will slope each way toward the trees thus tending to collect drifting snow where it is most needed.

The same care in planting should be taken that would be given in setting an orchard. Seedling trees, two years old, are better in most cases than large ones, as they will bear transplanting more readily, are easily handled, and the cost is much less than with the larger sizes. Trim off all broken and bruised roots with a sharp knife and cut back the top to correspond. Set the trees an inch or two deeper than in the nursery, and firm the soil about the roots.

As soon as planted, irrigate if water is available. If not, give a shallow cultivation to check surface evaporation from the soil.

Cultivation should be continued during the growing season, especially after each rainfall. This is particularly necessary on the plains or where water for irrigation can not be supplied. Such cultivation is calculated to keep a thin layer of fine, dry soil on the surface, which acts as a mulch to conserve moisture. Such care should be continued during the first three to five years, or until the trees shade the ground between the rows. A mulch of old straw at this time may be placed between the rows, and will assist the trees in keeping down the grass and weeds.

Pruning is not desirable, unless it be so done as to cause a thicker growth. Thus in the case of the willow, many smaller stems may be secured by cutting out the main trunk a foot or so above the ground when four or five years old. In this way a single, or, better still, a double row of willows, closely planted, may be used as a hedge, which will also serve as an effective wind-break.

GRASSHOPPERS UPON THE PLAINS.

BY C. P. GILLETTE

The western plains have long been noted for their hordes of grasshoppers. The reputation is chiefly due to the great swarms of the "Destructive" or "Rocky Mountain Locust" that used to fly out from the mountains in numbers sufficient to destroy all crops in a few hours, wherever they stopped. This pest is no longer to be feared in Colorado, but there are several species of locusts (grasshoppers) that are present every year and often in destructive numbers. The habits and remedies for the most of these may be given in a general way as follows:

Life History.—During the fall months the female locusts deposit their eggs in little pockets, an inch to an inch and a half deep, in the ground. The eggs are found in largest numbers along road sides, ditch banks and the borders of fields. They hatch about as soon as green vegetation starts enough to give the little hoppers plenty of tender, nutritious food.

If plenty of food is at hand, the little grasshoppers do not wander far from the place of hatching for a few days, and their presence may be noticed by the perforated and ragged leaves of weeds as well as cultivated plants where they are feeding.

By the middle of July, a few of these locusts will have wings, which means they are fully grown, but few, if any, eggs will be deposited before the middle or latter part of August. Very soon after a female has laid her eggs she dies, and there are some of the later individuals that do not finish egg-laying until they are killed by the cold, freezing nights late in November. There is but one generation or round of development of the locust in a year.

Destruction of Eggs.—The eggs of locusts are very soon killed by being exposed to the dry air and sunshine of Colorado, so if it is known that there are many of the eggs in meadows, alfalfa fields, along road sides or ditch banks, it is an excellent plan to plow or thoroughly harrow the infested ground during the late fall, winter, or early spring. It will pay well to harrow the alfalfa just because of the increased crop of hay that will result, even if there are no locust eggs.

Destroying the Locusts.—The little hoppers, when very abundant about the border of the fields or along ditch banks ,can be largely killed by a thorough spraying with arsenate of lead, 3 pounds to 50 gallons of water, or Paris green, ½ pound to 50 gallons, as for other insects. A narrow strip, not to exceed a rod in width, sprayed early in spring, will not endanger stock eating the hay later on, but care should be used not to put stock upon sprayed areas too soon.

Where straw is available, it may be spread lightly over ditch banks and other places where the hoppers are abundant and be burned In gardens and among potatoes and other vegetables poisoned bran can often be used with success. Mix 1 pound of Paris green with about 40 pounds of bran, add just water enough to moisten the whole, and then sow it broadsast where the hoppers are most numerous. If this poison is used, care must be taken to keep chickens and other domestic animals from the poison for some time.

One of the simplest and often a very effectual remedy is to grow plenty of chickens and turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

Hopper "dozers" or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112.

I shall always be glad to receive inquiries concerning insects that are doing damage in any part of the State. Send specimens of the insects when possible, with samples of their injuries.

RAISING HOGS ON THE PLAINS.

BY H. M COTTRELL.

Farmers living in the Plains regions of Colorado will find it advantageous to give special attention to the raising and fattening of hogs.

The surest grain crops under the dry land farming are barley, wheat, milo maize and Kaffir corn, all four are good feeds for the production of pork.

Barley is the best of all grains for the production of pork of fine quality and flavor. It requires less water to mature a crop than any of our other common grains, and when seeded early is the surest grain crop on the Plains. Many growers on the Plains report an average yield of 2,000 pounds of barley an acre, and this is sufficient to produce over 400 pounds of gain when fed to hogs.

Wheat will produce as much pork as the same weight of corn, and many farmers have found it profitable where rainfall is limited

to raise Durum wheat and fatten hogs with it. Wheat does not produce pork of the first quality and it is best to feed barley the last 30 days of fattening, as it makes the pork finer, the fat whiter, and greatly improves the flavor.

Rye is profitably fed in some sections. It will make good gains, but the hogs should be finished on barley.

Milo maize and Kaffir corn will produce about 90 per cent. of as much gain on hogs as will an equal weight of corn, and are very profitable grains to raise for feeding hogs. Both of these grains are constipating and need some laxative feed to be given with them. Alfalfa hay is one of the best feeds for this purpose, sorghum hay is good, as are also any kind of roots.

Hubbard squash is an excellent feed for fattening hogs and some Colorado farmers use it as an exclusive feed for this purpose, but better gains and finer quality of pork will be secured when some grain is given with it.

A mixture of two grains will give larger gains than the same weight of one grain fed alone.

Dairying is one of the surest and most profitable lines of farming on the Plains, and skim milk fed with grain to pigs and hogs is one of the best of feeds. Hog raising increases the profitableness of dairying.

Grain is high-priced in most sections of Colorado, and while a hog should have some grain every day of his life, at least half the weight of a 200-pound hog should be made from roughage—pasture or fodder. The best pasture is alfalfa, and there are few farms on the Plains but what have some spot where alfalfa will thrive if proper methods are followed, and seed from non-irrigated land is used.

Dwarf Essex rape stands drought fairly well if seeded as soon as the frost is out of the ground. Winter wheat and rye make good early pasture, and sorghum may be seeded in the spring in fields of rye or wheat and will furnish pasture after the grain has dried up.

Good alfalfa hay is the best winter roughage to feed hogs. It can be fed in a rack and will increase the gains and improve the flavor of the pork. In a test made by the writer, hogs fed all the grain they would eat gained 400 pounds, while those fed alfalfa hay and grain gained 600 pounds.

Where alfalfa hay is not available good, juicy, sorghum fodder improves the thriftiness of hogs and increases the gains.

Hogs should have access to salt and charcoal or coal at all times. and wood ashes are beneficial. Good water plentifully supplied is as essential in making gains as is grain.

The Plains section of Colorado has great advantages for raising hogs. The grains most profitable to grow there produce finer flavored pork than corn, and usually the grain can be marketed at a higher price when fed to hogs than when sold on the market. This is especially true where the quality of the grain is inferior.

Denmark sells eighteen million dollars worth of bacon a year to England alone. The Danish bacon sells for a considerably higher

price than the best quality of corn fed bacon. The Danish bacon is made from barley-fed hogs.

TYPES OF MILLING WHEAT FOR THE PLAINS.

BY W. H. OLIN.

Winter Wheat.—The Plains farmer has found in the past that wheat is to him a desirable cash crop and when acclimated seed of wheat types having known drouth resistant power, is used, the probabilities for harvest are increased.

The type of winter wheat which for the past five years has been giving best results is Turkey Red. It has a medium straw, a medium to short spike, a small kernel, but is recognized as one of the best of milling wheats. Nearly every mill in the state is ready to pay from 5 cents to 10 cents premium for this wheat, so it has a strong local trade, insuring farmers a good market for the threshed grain. This grain should be seeded on good summer cultured ground at such a time after the middle of September and before the middle of October, as local conditions render advisable. When moisture conditions are such that his wheat gets a good start before it goes into the winter, it has a stem and root growth which enables it to more readily withstand winter conditions and the desirable strength in the spring for sturdy growth. An appreciable amount of winter moisture is very desirable for this crop.

Early fall and late spring rains are essential for a fully developed crop and a satisfactory harvest. Use acclimated seed if possible. Some careful farmers in the vicinity of Holyoke, Vernon, Bennett, Byers and other localities of the Plains, have raised creditable winter wheat this past season, and the writer will be glad to assist, as far as possible, the new settler to get good quality acclimated seed grown under his local conditions.

When the seed bed is well prepared under summer culture conditions, good vital, acclimated seed is properly drilled in the seed bed, (do not broadcast) at least three weeks before the close of the growing season, the farmer has done his part well. This should be followed by cross-harrowing in the spring. This gives cultivation to the growing wheat and thereby invigorates it.

Get and keep pure quality seed.

Spring Wheat.—Kubanka Durum for the past four years has shown itself to be our most drouth-resistant spring wheat for the Plains. While Colorado millers have not used it very extensively for milling, several export dealers are lending encouragment to the growing of this grain, and an increasing export trade east and south seems assured. Besides, this grain is being utilized by many farmers, mixing it with other grains for feeding purposes.

It is our very best poultry food, and crushed and soaked with barley or rye, makes a very good hog food.

This wheat, when made into flour, furnishes a rich, nutritious flour, bread made from which has a rich, creamy color, a nutty flavor, holds moisture longer than bread from the common spring wheat flour, and tests made by the writer show that very satisfactory bread, biscuits and pastry can be made from straight Durum flour.

A few Kansas and Colorado millers are successfully milling this wheat, and should Plains settlers call for and use this flour, the growing and milling of Durum wheat on the Plains will be greatly encouraged.

There are fifteen types of Durum wheat grown in this country. Some types have little or no milling value. White Kubanka Durum (the type recommended for the plains) *will make good quality flour,* and also superior macaroni. This wheat should not be grown under irrigation where a hardy winter wheat has proven itself a well-acclimated grain. It is recommended for those regions of the Plains of Colorado where other wheats are not successfully grown. It is one of our most drouth-resistant spring grains, but is heavily bearded. Colorado No. 50 wheat and White Sonora are showing fairly good drouth-resisting power, but not equal to Kubanka Durum. Both of these are beardless types of spring wheat.

Seed your spring wheat on a well prepared seed bed as early as weather conditions will permit. The earlier seeded, usually the better the grain starts, and it is more likely to blossom and fill before the drying winds come to check development.

Plains farmers are urged to grow their own *bread,* as well as

RAINFALL ON THE PLAINS.

BY L. G. CARPENTER.

In some current discussion it seems to be forgotten that all moisture must come ultimately from the rainfall, and, therefore, unless increased by drainage or other source, the amount available for crops must be limited to the amount of rainfall or by the amount absorbed which is considerably less. While land favorably situated may have an advantage from its location, and derive water from neighboring land, there is no method of cultivation which will manufacture moisture. The most to be expected is to lessen the losses, by evaporation and otherwise, which normally take place, and possibly to take advantage of favorable location. In depressions or valleys, some water may be received, none the less important because invisible and underground, usually the drainage from higher land. In such locations, the crop may use much more than the local rainfall, hence where crops are

meat, and thus "Keep the wolf from the door."

grown below a ditch, they may receive additional waters no less effectively than by surface irrigation. To say they are raised by the natural rainfall is misleading, to say the least.

Many inquiries are asked concerning the amount of rainfall on the plains, and some misunderstandings are prevalent. These may best be answered by giving the records of a number of places where the rainfall has been measured for a series of years. Those which have the longest record are chosen.

To interpret the rainfall records, the distribution and character of the rainfall must be taken into account as well as the amount. It scarcely needs to be said that a moderate rainfall which falls mostly in the growing season, without long intervals between rain, moderate showers, is far more effective than a large rainfall coming principally in the cold season, or which comes in heavy showers at irregular and infrequent intervals. Sudden and heavy downpours are of little agricultural value for the effectiveness of a rain is largely measured by the amount which the soil absorbs and this absorption takes place at a slow rate, varying with the soil, but, say, one-tenth inch per hour. Showers of a few hundredths of an inch are of little value, for they penetrate only the surface of the soil, evaporate almost immediately, and thus are of practically no benefit. Hence moderate rainfalls, well distributed, during the growing months, are of the greatest value. A favorable feature of the distribution of the rainfall in Colorado, is that nearly 50 per cent comes in these growing months. On the divide between the Arkansas and the Platte rivers, more falls in the summer months of July and August. Speaking generally in respect to the plains, the storms of long continuance are mostly in the months of April and May or perhaps the early part of June and October, while the intermediate months of the summer have their precipitation principally in the form of thunder showers.

Even the average rainfall for any given month may in itself be misleading, and especially where the rainfall is moderate or small, and subject to occasional violent storms. The average may be far from indicating the probable quantity to be expected. More than half of the years will be below the average. A better index to the agricultural value of the rainfall is to know the certain surety of a given rainfall which can be depended on. We may take the record of April at Fort Collins to illustrate the difference. While the average for 25 years is 2.31 inches, the record shows that practically three out of four years (18 out of 24) have been below the average. Hence so far as this is a guide for the future, the probability is about three to one that in any given April, the rainfall will be below the average.

If, however, we count the Aprils with reference to the amount, we find that, for a quantity of about 1.44 inches, half of the Aprils have been above and half below. Tihs amount is the safer guide of what to expect. For lack of a better term, I have called this the agricultural mean as distinct from the ordinary average, and it is indicated at the foot of the table. Where there is little difference

between the average and the agricultural mean, it indicates that the rainfall in the month is quite certain.

The records which are given in connection with this bulletin are the records of the stations which have maintained the records for the longest period of time. These include Fort Collins and Denver, on the plains within a few miles of the foothills, and both at an elevation of practically 5,000 feet. Rocky Ford is in the Arkansas Valley about sixty miles east of Pueblo, at an elevation of 4,176 feet. Leroy, (elevation 4,380 feet), Wray, (elevation 3,531 feet) and Yuma, (elevation 4,147 feet), are in Northeastern Colorado; Cheyenne Wells in the Eastern Central (elevation 4,279 feet), and Hamps on the divide between the Arkansas and Platte rivers. The length of record of these stations ranges from 11 to 37 years.

A critical examination indiactes that when changes occur at one station they generally indicate a corresponding change at other stations, but that the increase or decrease is not the same. This is due to the fact that while there are many storms which are general in character, there are also local storms which affect a lesser area. Generally speaking, the rainfall decreases for some distance from the mountains on the plains, and then increases toward the eastern border of the state. It increases with elevation, and prominent ridges, like the divide between the Arkansas and Platte rivers, show an increase or change in the character of the distribution, which materially helps the availability of the supply.

While it is not safe to conclude that the rainfall of the whole eastern part of the state has increased becase the percipitation at one station has increased, yet generally, there is some parallelism.

An examination of the table indicates a marked increase in all the stations for 1905 and 1906 over the average for a period of years. This is shown by the following summary:

Place.	**No. Years on Record.**	**Average.**	**1905.**	**1906.**	**1907.**
Denver	37	13.37	17.68	16.84	11.83
Fort Collins	27	14.92	19.86	19.88	11.64
Wray	11	19.25	22.43	23.09	14.23
Hamps	14	14.56	23.60	19.07	10.56
Yuma	16	17.77	23.76	20.76	13.53
Leroy	17	16.06	22.18	21.80	16.57
Cheyenne Wells ...	16	16.58	18.31	19.46	9.72
Rocky Ford	18	13.15	14.39	14.66	13.59
		125.66	162.21	155.56	101.67

The tables give the monthly rainfall. At the bottom is given the average for the whole period of the record. Manifestly in comparing the percipitation in two different stations, it is important that the same years be considered at both placs, or the same months. These tables were made up in the summer of 1907 and thus 1907 was omitted. For convenience, it is given in a separate table by months, but not used in determining the averages or agricultural mean.

PRECIPITATION AT DENVER, COLORADO. *U. S. Weather Bureau*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1870	1.80	1.70	0.70	2.80	0.34	0.52	0.51	0.12	2.85	0.68	0.54	0.73	13.29
1871	0.46	0.23	1.81	1.01	2.56	0.05	0.51	0.27	1.18	0.40	3.10	0.77	12.35
1872	0.55	0.22	1.71	2.09	3.74	2.07	2.69	1.75	1.57	0.68	0.69	0.29	18.05
1873	0.13	0.24	0.22	2.43	0.75	2.24	2.00	1.41	0.89	0.73	0.16	0.61	11.81
1874	0.84	0.53	0.49	1.70	2.43	1.21	3.35	0.68	1.34	0.64	0.08	0.17	13.46
1875	0.38	0.60	0.39	2.24	1.94	0.43	4.32	1.97	2.89	0.22	1.28	0.59	17.25
1876	0.21	0.11	1.80	1.22	8.57	1.10	1.16	2.03	0.60	0.12	1.50	1.70	20.12
1877	1.90	0.40	1.40	2.77	2.30	1.93	0.23	1.30	0.38	2.15	0.73	0.79	16.28
1878	0.10	0.48	1.82	0.05	2.90	2.78	1.38	2.25	1.23	0.80	0.67	1.05	15.51
1879	0.40	0.39	1.00	2.62	3.36	0.32	0.64	1.38	0.02	0.19	0.21	0.33	10.86
1880	0.38	0.32	0.21	0.31	1.11	1.22	1.38	1.46	0.89	1.37	0.83	0.10	9.58
1881	0.49	1.22	0.87	0.50	2.21	0.09	2.50	2.33	0.57	0.32	1.68	0.00	12.78
1882	0.57	0.20	0.20	1.47	2.98	4.96	0.66	1.20	0.06	0.75	0.71	0.73	14.49
1883	2.35	0.45	0.21	3.10	4.30	0.85	2.27	0.75	1.08	1.49	0.32	2.32	19.49
1884	0.22	0.86	0.93	3.33	4.61	1.47	0.65	1.71	0.13	0.21	0.19	0.76	15.07
1885	0.41	0.75	0.97	4.94	2.13	0.66	1.33	1.18	1.22	0.73	0.55	1.08	15.95
1886	0.62	0.72	2.36	2.79	0.09	2.26	0.50	1.62	0.98	0.33	1.93	0.87	15.07
1887	0.67	0.30	0.23	2.16	1.13	0.53	2.49	2.68	0.97	0.97	0.22	0.14	12.49
1888	0.11	0.37	1.15	1.71	2.66	0.29	0.41	1.51	0.11	0.77	0.33	0.09	9.51
1889	0.50	0.70	0.40	1.34	3.44	1.88	2.94	0.33	0.28	2.11	0.53	0.30	14.75
1890	0.18	0.46	0.35	2.50	2.01	T	0.79	1.89	0.17	0.64	0.30	0.04	9.33
1891	1.60	0.27	3.10	2.49	4.15	2.93	0.59	2.84	0.73	0.48	0.69	1.56	21.43
1892	0.40	0.75	1.20	1.75	2.14	1.33	1.19	0.58	T	3.92	0.44	1.32	15.02
1893	0.05	0.83	0.23	0.87	3.09	0.13	1.14	0.35	0.05	0.84	0.55	0.35	8.48
1894	0.18	0.90	0.70	3.30	3.00	0.39	2.11	1.86	1.55	0.19	0.22	0.69	15.09
1895	0.32	0.48	1.19	1.19	2.86	2.65	4.28	0.76	0.98	1.13	0.27	0.01	16.12
1896	0.25	0.24	1.43	0.93	1.27	0.89	2.80	0.97	1.81	0.84	0.10	0.31	11.84
1897	0.58	0.82	0.90	1.31	3.15	2.16	2.06	1.44	0.44	1.64	0.24	0.63	15.37
1898	0.20	0.68	0.28	1.20	4.88	0.94	0.67	0.96	0.28	1.05	0.85	0.99	12.98
1899	0.65	0.58	1.10	0.75	0.15	0.47	1.92	1.78	0.20	1.01	T	0.72	9.33
1900	0.13	0.55	0.63	8.24	0.53	1.87	1.30	0.05	0.87	0.33	0.37	0.42	15.29
1901	0.05	0.06	0.88	1.96	1.18	2.09	0.01	1.30	0.22	0.46	T	0.89	9.10
1902	0.17	0.38	0.63	0.60	1.98	1.89	1.24	0.76	3.70	0.80	0.61	0.59	13.35
1903	0.12	0.42	0.87	0.81	0.75	1.62	1.36	1.35	0.56	1.34	0.07	0.23	9.50
1904	0.04	0.17	0.94	0.74	3.27	3.54	2.13	0.60	1.77	0.40	0.04	0.41	14.05
1905	0.99	0.35	3.07	4.95	2.65	0.61	1.55	0.67	0.49	2.31	0.04	T	17.68
1906	0.17	0.06	1.88	3.67	1.45	1.51	1.21	0.88	2.72	1.98	1.30	0.01	16.84
Average 37 years	0.52	0.51	0.97	2.10	2.49	1.40	1.57	1.27	0.97	0.95	0.60	0.61	13.96
Average 20 years	0.37	0.47	1.06	2.12	2.28	1.38	1.61	1.18	0.89	1.16	0.36	0.49	13.37
Max.	2.35	1.70	3.10	8.24	8.57	4.96	4.28	2.68	3.70	3.92	3.10	2.32	.....
Min.	0.04	0.06	0.21	0.05	0.09	T	0.01	0.05	T	0.19	T	0.00	.....
Agr. Mean	0.38	0.45	0.90	1.75	2.43	1.22	1.33	1.30	0.87	0.75	0.44	0.59	12.41

PRECIPITATION AT AGRICULTURAL COLLEGE, FORT COLLINS, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.02	0.20	.....
1873	0.25	0.16	0.00	1.20	2.30	1.50	1.30	0.85	0.75	0.42	0.20	0.17	9.10
1874	0.06	0.43	1.29	0.77	2.95	0.65	3.15	0.25	0.00	1.00	0.02	0.00	10.57
1879	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.75	0.15	0.60	.....
1880	0.72	1.09	0.38	0.94	0.60	0.86	1.80	0.37	1.47	2.07	1.10	0.10	11.50
1881	1.10	0.55	1.45	.....	.....	.....	.....	.....			.....	.....	.....
1882	.....	.....	0.17	.....	4.67	3.07	1.76	0.89	2.51	0.82	0.29	.....	.....
1883	1.00	1.50	0.68	.....	2.51	3.18	.....	1.78	1.00	1.29	T	1.33	.....
1884	1.10	0.70	1.15	3.94	4.84	.....	.....	.....	.....	0.10	1.80	0.35	.....
1885	1.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.69	1.18	0.33	.....
1887	0.86	0.23	0.25	1.10	1.23	1.96	3.05	2.12	0.54	0.43	0.15	0.00	11.92
1888	0.29	0.36	0.73	1.23	3.39	0.47	0.60	1.01	0.29	0.88	0.38	0.16	9.79
1889	0.21	0.34	0.65	2.07	3.39	2.06	0.79	0.95	0.42	3.16	0.43	0.01	14.48
1890	0.13	0.21	0.22	3.92	1.19	0.12	1.27	3.14	0.07	0.70	0.32	0.12	11.41
1891	2.32	0.16	1.20	2.14	4.07	1.30	0.17	2.05	1.02	0.20	0.60	0.46	15.70
1892	0.60	1.29	1.52	1.60	4.83	2.42	1.32	0.22	0.14	0.93	0.23	0.35	15.45
1893	0.02	0.54	0.14	1.66	1.92	0.26	0.64	0.92	0.18	0.16	0.55	0.12	7.11
1894	0.25	0.60	0.67	0.89	3.09	0.42	1.72	1.53	2.29	T	0.14	0.76	12.36
1895	0.24	1.52	0.54	1.36	3.62	3.65	3.75	1.45	0.47	1.06	0.40	0.01	18.07
1896	0.43	0.03	1.73	1.26	1.68	3.05	3.05	2.20	1.55	0.49	0.05	0.24	15.76
1897	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
1898	0.14	0.08	0.50	1.08	3.65	1.37	0.50	0.98	0.50	0.82	1.24	0.17	11.03
1899	0.66	1.04	1.50	1.10	1.01	1.03	4.95	0.99	0.21	3.23	T	0.47	16.19
1900	0.25	1.12	1.07	10.56	1.75	0.82	1.14	0.16	1.92	0.24	0.07	0.11	19.21
1901	0.19	0.38	1.88	3.62	7.47	2.35	0.71	0.72	2.10	0.36	0.02	1.37	21.17
1902	0.32	0.15	1.50	0.61	2.13	2.43	1.31	0.67	7.12	1.15	0.27	0.77	18.43
1903	0.16	1.60	1.03	1.50	0.63	2.23	1.06	0.86	0.87	1.70	0.18	0.07	11.89
1904	0.04	0.34	0.51	0.89	5.37	1.68	1.99	0.71	1.09	0.39	0.00	0.12	13.13
1905	0.29	0.35	1.75	6.32	4.13	0.64	2.18	1.25	0.28	2.60	0.07	T	19.86
1906	0.01	0.03	2.44	4.30	2.40	1.80	1.96	0.80	3.08	1.59	1.35	0.12	19.88
Average	0.50	0.59	1.00	2.31	2.96	1.64	1.78	1.14	1.22	1.04	0.41	0.33	14.92
Average 20 Years	0.38	0.55	1.10	2.43	2.95	1.58	1.74	1.22	1.24	1.04	0.36	0.34	14.93
Max.	2.32	1.60	2.44	10.56	7.47	3.65	4.95	3.14	7.12	3.23	1.35	1.37	.....
Min.	0.01	0.03	0.14	0.61	0.63	0.12	0.50	0.16	0.07	T	O	0.00	.....
Agrl. Mean, 20 Years	0.24½	0.34½	1.05	1.44½	2.74½	1.68½	1.31½	0.98½	0.64½	0.78½	0.25	0.14	11.63

Observers—1880, F. J. Annis; 1881, A. E. Blount; 1882-5, C. F. Davis; 1886-7, E. Mead; 1888-1906, L. G. Carpenter, R. E. Trimble, Assistant.

PRECIPITATION AT WRAY, YUMA COUNTY

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890	.....	.....	T	T	4.44	1.42	0.62	0.25	1.09	0.45	0.25	T	.....
1891	1.80	0.50	1.90	4.68	2.02	4.55	2.52	0.45	1.24	O	0.20	0.83	20.69
1893	.....	.....	.....	0.03	2.12	1.00	.....	.....	.....	.....	.....	.....	.....
1895	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0.12	0.32	.....
1896	0.47	0.02	0.66	4.83	1.64	3.77	1.13	1.47	1.01	1.37	0.06	0.20	16.63
1897	0.28	0.26	1.79	1.64	3.34	4.79	1.79	2.27	0.73	2.92	0.07	0.31	20.19
1898	0.06	0.07	0.83	1.73	5.47	2.98	1.88	2.56	2.33	0.25	0.26	0.29	18.71
1899	0.63	0.07	0.50	0.62	1.96	1.83	2.18	1.38	0.08	T	1.16	0.33	10.74
1900	0.16	0.90	0.33	6.00	0.61	2.35	4.57	2.60	0.15	0.03	0.20	0.34	18.24
1901	T	1.37	2.51	4.02	0.28	3.40	2.05	5.36	2.11	0.43	T	0.91	22.44
1902	0.20	0.74	1.05	0.74	7.00	5.69	3.33	2.71	3.73	1.05	0.16	0.59	26.99
1903	0.25	1.98	0.16	0.54	1.95	1.55	5.16	1.48	0.69	0.34	0.25	T	14.35
1904	T	0.58	0.04	2.46	2.02	6.25	2.00	1.26	1.74	1.19	0.05	0.20	17.79
1905	0.04	0.05	3.10	5.12	2.59	3.19	2.98	0.93	2.19	1.64	0.60	T	22.43
1906	0.55	0.62	1.88	4.82	3.20	2.57	1.62	3.57	1.71	1.43	0.83	0.29	23.09
Means	0.24	0.61	1.17	2.96	2.73	3.49	2.61	2.33	1.50	0.97	0.33	0.31	19.25
Agrl. Mean	0.20	.58	.83	2.46	2.02	3.19	2.05	2.27	1.71	1.05	0.20	0.26	16.82
Max. for Month	0.63	1.98	3.10	6.00	7.00	6.25	5.16	5.36	3.73	2.92	1.16	0.91	.....
Min. for Month	T	0.02	0.04	0.54	0.28	1.55	1.13	0.93	0.15	T	T	T	.....

Established by the Colorado State Weather Bureau. Observer—J. C. Tuomey.

PRECIPITATION AT HEMPS, ELBERT COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1893	0.02	0.08	0.02	0.24	1.60	0.70	3.07	1.23	0.27	0.16	0.04	0.19	7.62
1894	0.07	0.29	0.54	1.11	4.10	0.51	1.65	1.23	1.19	0.05	0.02	0.17	10.93
1895	0.15	0.42	0.28	0.85	2.05	3.79	4.07	2.08	0.12	0.15	0.10	0.11	14.70
1896	0.52	0.30	1.25	1.22	1.05	0.70	3.42	2.80	0.65	0.57	0.02	0.28	12.78
1897	0.14	......	......	0.49	0.70	1.68	1.35	6.21	0.42	0.96	T	0.22	.....
1898	0.04	0.02	0.20	0.96	3.80	1.03	1.84	1.61	1.17	0.90	0.28	0.72	12.57
1899	0.90	0.19	2.26	1.30	0.30	1.13	2.50	2.19	0.19	0.49	0.51	0.71	12.67
1900	0.09	0.60	0.86	11.30	1.25	2.20	1.94	0.91	0.65	0.09	0.25	1.03	21.17
1901	0.34	0.07	1.50	4.24	0.83	0.98	0.38	2.58	0.52	0.81	T	0.69	12.89
1902	0.23	0.13	1.37	1.03	4.97	2.52	0.62	2.68	1.37	0.91	0.22	0.98	17.03
1903	0.20	0.76	0.21	0.53	0.75	3.73	1.99	1.40	0.44	0.53	0.09	0.14	10.77
1904	0.03	0.07	0.06	0.71	3.08	2.70	2.69	3.09	2.37	0.62	T	0.09	15.51
1905	0.08	0.58	3.48	4.86	3.98	2.04	4.72	1.27	2.23	0.23	0.13	T	23.60
1906	0.38	0.90	2.25	4.17	0.98	1.44	3.09	2.56	2.23	0.64	0.38	0.05	19.07
Mean	0.23	0.32	1.10	2.35	2.10	1.79	2.38	2.27	0.98	0.51	0.15	0.38	14.56
Agril. Mean	0.14½	0.29	0.86	1.16½	1.42½	1.56	2.24½	2.13½	0.65	0.55	.11½	.20½	11.34
Max. for month	0.90	0.90	3.48	11.30	4.97	3.73	4.72	6.21	2.37	0.96	0.51	1.03	.....
Min. for month	0.02	0.02	0.02	0.24	0.30	0.51	0.38	0.91	0.12	0.05	T	T	.....

Established by U. S. Weather Bureau. Observer—W. Hamp.

PRECIPITATION AT YUMA, YUMA COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	2.35	0.50	3.63	2.90	4.21	5.23	2.98	0.75	0.64	0.05	0.13	1.25	24.62
1892	0.80	1.55	0.80	3.20	3.46	1.20	4.44	1.50	0.35	1.00	T	0.62	18.92
1893	T	0.90	0.70	0.38	2.57	1.30	2.10	0.95	T	0.40	0.41	0.55	10.26
1894	0.50	0.90	1.10	0.68	0.04	1.85	0.80	0.70	2.85	O	0.22	0.70	10.34
1895	1.20	1.70	0.50	1.10	2.76	2.73	3.22	1.77	0.55	0.10	0.60	0.10	16.33
1896	0.60	0.20	1.25	1.82	2.06	3.98	2.59	1.04	1.02	0.78	0.30	0.20	15.84
1897	0.37	0.40	2.80	0.80	1.62	4.44	1.78	2.44	T	2.55	0.10	1.00	18.30
1898	0.30	0.20	0.31	1.55	5.80	2.70	1.86	3.62	1.00	1.50	1.45	1.10	20.39
1899	1.38	0.60	1.18	0.97	1.23	3.03	2.63	2.22	0.17	0.03	0.90	0.27	14.61
1900	0.14	1.55	0.61	8.67	1.39	0.72	1.81	2.22	0.16	0.03	0.17	0.51	17.98
1901	T	1.11	2.44	3.90	0.31	3.51	1.61	6.53	0.36	0.39	T	0.57	20.73
1902	0.07	0.56	0.95	0.67	3.76	1.91	2.70	3.33	1.68	0.78	0.20	0.73	17.34
1903	0.14	1.88	0.20	0.40	1.00	2.10	2.65	3.12	0.35	0.10	0.36	0.09	12.39
1904	T	0.70	0.25	3.37	4.26	4.98	1.65	1.28	2.92	1.07	T	0.27	20.75
1905	0.31	0.13	4.47	4.27	3.64	2.16	4.45	0.73	1.91	1.64	0.05	O	23.76
1906	0.38	0.51	2.36	4.45	2.01	1.98	2.44	1.23	1.19	2.92	1.17	0.12	20.76
Means	0.53	0.84	1.47	2.45	2.51	2.74	2.48	2.09	0.95	0.83	0.38	0.50	17.77
Agril. Means	0.34	0.65	1.02½	1.68½	2.31½	2.43	2.51½	1.63½	0.59½	0.59	0.21	0.53	14.52
Max. for month	2.35	1.88	4.47	8.67	5.80	5.23	4.45	6.53	2.92	2.92	1.45	1.25	.....
Min. for month	T	0.13	0.20	0.38	0.04	0.72	0.80	0.70	T	O	T	O	.....

Established by the Colorado State Weather Bureau. Observer—Geo. W. Custer.

PRECIPITATION AT LE ROY, LOGAN COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	......	......	......	4.40	2.09	3.38	0.36	2.56	0.83	0.37	0.60	0.10	.....
1890	0.30	0.48	0.01	2.80	1.03	1.96	0.47	1.41	T	0.98	0.48	0.01	9.93
1891	1.70	1.00	1.99	1.35	5.02	4.84	4.69	2.89	0.67	0.14	0.37	0.94	25.60
1892	0.89	2.24	0.80	4.02	2.53	1.48	3.07	1.83	0.84	1.66	0.10	0.65	20.11
1893	0.05	1.20	0.87	0.46	2.73	1.25	1.75	0.61	0.41	0.41	0.48	0.94	11.16
1894	0.35	0.46	0.95	0.98	0.17	0.75	1.16	0.47	1.06	0.08	0.26	0.65	7.34
1895	0.73	0.88	0.40	2.43	2.05	2.94	2.56	0.79	0.42	0.11	0.47	0.12	13.90
1896	0.53	0.24	1.20	1.91	2.36	3.77	1.33	0.87	0.86	0.90	0.20	0.01	14.18
1897	0.60	0.72	1.66	1.77	3.08	2.24	1.39	2.79	0.41	2.61	0.40	0.81	18.48
1898	0.38	0.26	0.67	1.07	4.60	1.31	2.83	1.13	1.27	0.54	0.65	0.27	14.95
1899	0.50	0.33	1.21	1.57	2.93	0.28	2.17	2.38	0.88	0.30	0.23	0.44	13.22
1900	0.10	0.96	0.12	7.27	2.10	0.78	1.68	0.99	0.35	0.07	0.12	0.20	14.74
1901	0.06	0.49	1.60	2.92	0.72	2.52	0.97	4.03	0.27	0.47	T	0.89	14.94
1902	0.12	0.72	1.23	1.28	3.16	1.82	0.98	3.70	3.46	0.78	0.09	0.99	18.33
1903	0.18	1.50	0.26	1.12	0.80	1.07	1.71	3.44	0.62	0.29	0.06	0.03	11.08
1904	0.10	0.26	0.35	1.99	3.97	4.39	3.46	1.17	2.96	1.55	0.04	0.05	20.29
1905	0.17	0.30	3.28	4.70	3.88	2.48	2.56	1.96	0.78	1.93	0.12	0.02	22.18
1906	0.23	0.43	1.38	4.53	1.96	1.35	1.88	2.83	2.70	2.69	1.29	0.53	21.80
Means	0.41	0.73	1.06	2.59	2.51	2.14	1.95	2.00	1.04	0.88	0.33	0.42	16.06
Agril. Mean	0.23	0.49	0.95	1.95	2.44½	1.89	1.81½	1.89½	.80½	.50½	.24½	.35½	13.58
Max. for month	1.70	2.24	3.28	7.27	5.02	4.84	4.69	4.03	3.46	2.69	1.29	0.99	.....
Min. for month	0.05	0.24	0.01	0.46	0.17	0.28	0.36	0.47	T	0.07	T	0.01	.....

Established by the Agricultural Experiment Station. Observer—Charles Green.

PRECIPITATION AT ROCKY FORD, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	0.36	0.12	0.67	2.12	1.75	0.75	4.50	1.28	0.26	1.68	0.77	0.04	14.30
1890	0.34	0.15	0.15	2.97	0.29	0.77	1.14	0.74	0.08	0.00	0.30	0.00	6.93
1891	1.50	0.00	1.80	0.43	3.52	2.31	0.74	0.73	1.75	0.21	0.20	1.77	14.96
1892	0.50	0.80	1.50	0.73	3.26	3.31	1.99	3.10	0.00	0.95	0.50	0.46	17.10
1893	0.02	0.08	0.80	0.25	0.70	0.40	10.26	3.20	0.30	0.25	T	0.50	16.76
1894	0.10	0.95	0.45	0.60	4.25	0.70	1.40	0.25	0.80	0.00	0.04	0.65	10.19
1895	0.27	0.65	0.07	0.35	1.90	0.52	4.87	1.86	T	0.85	0.20	0.57	12.11
1896	0.32	0.18	0.23	0.55	1.12	0.47	2.09	0.47	1.85	1.96	0.00	0.70	9.94
1897	0.75	0.37	0.20	0.44	....	....	....	0.73	0.79	2.64	0.19	1.06	.....
1898	0.40	0.00	0.16	1.06	2.71	3.16	3.52	0.92	1.55	1.36	0.37	0.96	16.17
1899	0.98	0.55	0.32	0.28	0.99	0.78	7.00	2.22	1.43	0.63	2.40	0.98	18.56
1900	T	0.52	0.37	7.15	2.28	1.47	1.77	1.05	0.08	0.60	0.06	0.24	15.59
1901	0.20	0.10	1.00	2.36	1.34	0.23	1.48	0.74	0.48	0.25	0.00	0.50	8.68
1902	0.18	0.57	1.78	0.18	4.02	0.60	0.72	2.72	0.46	0.80	0.41	0.33	12.77
1903	T	1.05	0.18	0.56	0.28	3.94	0.42	0.87	T	1.62	0.26	0.22	9.40
1904	T	T	0.77	0.81	2.03	2.20	1.75	0.33	2.34	0.50	0.00	0.31	11.04
1905	0.05	0.11	2.11	4.67	2.13	1.56	1.30	0.45	1.48	0.10	0.41	0.02	14.39
1906	0.23	0.10	0.92	5.59	0.59	0.54	2.05	1.21	1.64	1.57	0.22	T	14.66
Normal	0.34	0.35	0.75	1.73	1.95	1.39	2.76	1.27	0.85	0.89	0.35	0.52	13.15
Agril. Mean	0.25	.16	.56	0.66	1.90	0.77	1.77	.90	0.64	0.72	0.21	0.48	9.02
Max.	1.50	1.05	2.11	7.15	4.25	3.94	10.26	3.20	2.34	2.64	2.40	1.77	.....
Min.	T	O	0.07	0.18	0.28	0.23	0.42	0.25	O	O	O	O	.....

Established by Agricultural Experiment Station. Observers—F. L. Watrous, 1889—August, 1892; F. A. Huntley, August, 1892—September, 1895; P. K. Blinn, September, 1895—September, 1897; W. F. Crowley, September, 1897—March, 1898; H. H. Griffin, March, 1898—June, 1903; P. K. Blinn, June, 1903.

PRECIPITATION AT CHEYENNE WELLS, CHEYENNE COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	......	......	1.00	2.00	3.10	2.32	4.97	2.35	1.92	T	T	2.25	.....
1892	0.10	0.60	2.25	0.50	......	3.63	2.09	4.40	T	0.45	0.20	0.96	.....
1893	0.05	T	T	......	1.10	1.15	2.50	1.64	0.68	T	0.30	0.03	.....
1894	T	1.30	0.10	0.62	2.36	0.48	1.99	1.03	0.14	0.14	T	0.55	8.41
1895	0.67	0.27	0.16	1.67	1.49	3.00	6.38	1.22	T	0.21	0.30	0.42	15.79
1896	0.45	T	0.71	3.41	2.28	3.03	2.27	3.07	0.84	0.78	T	0.60	17.44
1897	0.26	0.10	1.58	1.20	1.44	2.22	4.19	3.24	0.92	2.73	0.10	0.20	18.18
1898	0.03	0.00	0.61	1.10	5.56	3.95	2.09	1.33	2.00	0.48	0.50	0.48	18.13
1899	0.47	0.36	0.39	0.03	2.88	1.89	3.67	0.55	.78	T	2.49	0.55	14.06
1900	0.03	0.67	0.56	9.95	0.80	2.47	2.02	0.30	1.31	0.22	T	0.18	18.51
1901	0.15	0.38	0.71	4.02	1.18	0.90	2.63	2.59	1.12	0.49	0.02	0.25	14.44
1902	T	0.25	1.92	0.78	3.12	2.53	1.42	6.06	0.20	1.32	O	0.75	18.35
1903	0.34	0.79	0.23	0.94	3.71	2.63	1.87	1.89	T	T	0.75	0.13	13.28
1904	T	T	0.11	1.59	2.51	4.78	3.39	4.89	4.26	0.99	0.00	0.29	22.81
1905	0.14	0.35	2.00	5.16	2.13	2.58	2.02	1.12	2.41	0.40	0.00	T	18.31
1906	0.21	0.24	0.89	3.77	1.24	3.00	4.26	2.39	2.36	0.90	0.20	T	19.46
Means	0.19	0.35	0.83	2.45	2.33	2.54	2.98	2.38	1.18	0.57	0.30	0.48	16.58
Agril. Means	0.14	0.27	0.71	1.59	2.28	2.55½	2.29½	2.12	0.88	0.42½	0.06	0.35½	13.79
Max. for month	0.67	1.30	2.25	9.95	5.56	4.78	6.38	6.06	4.26	2.73	2.49	2.25	.....
Min. for month	T	O	T	0.03	0.80	0.48	1.42	0.30	T	T	O	T	.....

Established by the Agricultural Experiment Station. Observers—J. B. Robertson, 1891—April, 1896; J. E. Payne, April, 1896—October, 1901; L. M. Parker, October, 1901—June, 1902; J. B. Robertson, June, 1902.

MONTHLY RECORD OF PRECIPITATION, 1907

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Denver	0.46	0.33	0.54	2.91	2.93	1.15	1.52	0.23	0.74	0.17	0.40	0.45	11.83
Fort Collins	0.23	0.36	0.69	2.80	2.44	0.44	2.28	1.27	0.58	0.08	0.44	0.03	11.64
Wray	0.12	0.02	0.24	0.94	2.17	1.53	3.39	3.80	1.27	0.03	0.14	0.58	14.23
Hamps	0.15	T	0.27	2.38	1.85	0.65	2.59	1.06	0.74	0.02	0.20	0.65	10.56
Yuma	0.28	0.02	0.33	0.94	1.43	2.44	3.44	2.58	1.44	0.04	0.24	0.35	13.53
LeRoy	0.12	0.05	0.25	0.97	2.85	2.67	2.24	4.19	1.88	T	0.66	0.69	16.57
Cheyenne Wells	T	T	0.13	0.72	1.10	2.86	1.98	0.95	1.28	0.25	0.25	0.20	9.72
Rocky Ford	T	T	0.00	1.84	1.85	0.69	4.96	0.78	0.33	0.88	2.00	0.26	13.59

Press of the Fort Collins (Colo.) Express.

Bulletin 124 July, 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

COLORADO FODDERS

AN EXAMINATION INTO THEIR COMPOSITION AND COMPARATIVE VALUES

BY

W. P. HEADDEN

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INTRODUCTORY

In the following pages, I have endeavored to state my results fully enough to enable the reader to clearly understand my interpretation and have, at the same time, given the data so fully that he may draw his own conclusions, and judge whether mine are justified or not.

In this work I have had no predecessor to follow, so far as I know. The study of the chemical composition of timothy hay presented by the Pennsylvania Experiment Station is quite different from the present work, and I have not taken up timothy hay in detail, for reasons given in the proper place. The only attempt to determine the digestibility of the different extracts of any fodder that I remember to have seen mention of, was made in France. I do not recall the fodder or fodders studied or the scope of the investigation.

I do not know that any similar attempt to study the calorific value of the various portions of the fodders and the relative amounts of heat furnished by them, their coefficients of appropriation, has been made.

I have given the analytical data as fully as possible, including the ordinary fodder analyses of both the fodders and the feces, similarly their ultimate analysis, the analysis of their ashes, and what I have, for the purpose of this bulletin, designated as their proximate analysis. By proximate analysis, I mean the division of the fodder into different portions by means of the following solvents: 80 per cent. alcohol, cold water, hot water with subsequent addition of malt extract, 1 per cent. hydric chlorid, 1 per cent. sodic hydrate and chlorin in the presence of water, with subsequent washing with water, boiling sodic hydrate, 1 per cent. solution, and sulfurous acid. The portion which resisted these successive treatments has been designated as residue or cellulose.

The heat or energy, given in small calories, removed by these successive treatments, and the percentage of this heat value appropriated by the animals have been studied in detail for three of the fodders, alfalfa, corn fodder and the saltbush, *Atriplex argentea*.

The distribution of nitrogen and also that of the furfurol, in these various extracts has been determined, but no attempt has been made to distinguish between arabinose and xylose, all being calculated as xylan. Determinations of mucic acid were made on these fodders, and the sugar obtained by treating the alfalfa hay with 1 per cent. hydric chlorid has been considered as being derived from galactan, which is also probably present, according to our results, in some of the other fodders.

The reducing power of the sodic hydrate extract has been indicated as xylan with an interrogation point, because it is very probably not derived from xylan. The quantity of this sugar is altogether insignificant, except in the case of the saltbush, in which it is relatively large.

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By W. P. HEADDEN

SEC. 1. In Bulletin No. 39 of this Station, I endeavored to study alfalfa, clover, pea-vine, and our native hay, but particularly alfalfa hay with special regard to the carbohydrates, including under this term the crude fibre and nitrogen-free extract.

§2. In Bulletin No. 93 I have given the results of experiments on the digestibility of alfalfa, timothy and native hay, also on the saltbush, *Atriplex argentea,* corn fodder and sorghum.

§3. In Bulletin 93, I followed the beaten path and gave the coefficients of digestion as obtained for the usual groups, proteids, crude fibre, nitrogen-free extract, etc. In the present bulletin, I shall take up the same hays and fodders treated of in Bulletin No. 93, but I shall consider them from the standpoint of Bulletin No. 39, following the same general method that I used in that work, but extending it very considerably.

§4. While it might be of scientific interest to study the ether extract, it is not a very important factor in the study of the coarse fodders presented in this bulletin as it, at most, amounts to only a small percentage of these fodders, usually to less than three per cent., and these three per cent. are composed of fats, waxes, coloring and other matters, none of which are involved in the questions which form the object of this study.

§5. I have discovered no good reason for taking up the extract by absolute alcohol, so I began the work by extraction with boiling 80 per cent. alcohol, which removes coloring matter, sugars and extractives. We found that extraction with four portions of alcohol, boiling each portion 20 minutes, was quite sufficient to exhaust the sample. We used 10 grams of hay and 450 c. c. of alcohol. The amount extracted by the fourth portion of alcohol amounted to only 0.30 of one per cent. of the air dried hay.

§6. We attempted to evaporate the extracts to dryness and weigh them, but in checking against the weight of the dried residue we found a difference of about two per cent., *i. e.,* the dried extracts were about this much too low. After considerable work to see if we could not obtain better agreement between the direct weighings of the extracts and the weight of the remaining hay, we decided to take the loss of weight as indicated by the residual hay as the weight of the material extracted. Had we been trying to obtain results to be expressed in terms of the extract, this method would of course not be admissable, but as we have expressed all results in terms of

the air dried hay or fodder, this method has the patent advantage of giving every percentage upon a basis which can be easily duplicated within quite narrow limits which we found would be attended with considerable difficulty if we used the weight of the extracts obtained, as each one showed a deficit for which we could not account. The weight of the residual portion of the hay seemed, furthermore, to be less subject to change, debarring the absorption of moisture which is comparatively easily guarded against, than that of the extract.

§7. As already stated, the boiling, 80 per cent. alcohol extracted the hays readily and even the first portion removed practically all of the coloring matters which, particularly in the case of alfalfa, was large and difficult to remove from the extract.

§8. It was not possible for us to prosecute any examination of these coloring matters, but it was necessary that we should remove them completely from the solution before we could proceed to test for sugars. The matter of decolorizing these solutions proved to be a difficult one. I first tried the effect of adding potassic aluminate and the precipitation of the aluminic hydrate by passing carbon-dioxid through the solution. My idea was that the precipitating aluminic hydrate might carry down all of the coloring matter, this, however, did not prove to be the case and the filtrate from the $Al_2(OH)_6$ had a bright yellow-red color. We pursued this a little further but the results, while interesting in themselves, did not advance the work in hand.

§9. Though I desired to avoid the use of basic acetate of lead, it proved to be the most effective agent in removing the yellow coloring matter, the filtrate however, was green and worked badly with the Fehling's solution, yielding a flocculent precipitate which may have contained cuprous oxid, it probably did, but the precipitate was essentially something else. We found that the addition of cupric sulfate removed the green coloring matter completely, yielding a colorless solution, provided no excess of the cupric sulfate had been added. The use of the basic acetate of lead and cupric sulfate worked well.

In Bulletin 39, I recorded the observation that the reducing power of such extracts are greatly diminished by the addition of basic acetate of lead but that I failed to detect any sugar in the precipitate.

§10. In the present work, it was imperative to establish one fact, *i. e.*, that the combined use of the lead and copper salts did not in any way affect the quantity of sugar, sucrose, present either by removing it with the precipitate or causing its inversion.

§11. In order to establish this point, several portions of the extract which had been made up to a given volume, after the alco-

hol had been distilled off, were taken and a weighed portion of pure sugar added to some of them. All the portions were then decolorized by the use of lead acetate, sodic sulfate and cupric sulfate, always added in this order, the precipitate filtered off and washed, the excess of copper removed by H_2S and the H_2S expelled by passing $C\ O_2$ through the solution, the two last operations were quite unnecessary, but I thought that it could happen that I might wish to remove the copper and subsequently the $H_2\ S$ in this manner and so I included them in this test. The results showed that the sugar was wholly unchanged both in character and quantity by these operations. This method was therefore adopted, as the substances which exert a reducing action upon the Fehling solution and are removed by these precipitants are neither glucose nor saccharose, the presence and quantity of which I wished to establish. The other substances are of course included in the extract yielded by the hay.

§12. The total reducing power of the cold water extract after inversion by heating with hydric chlorid is attributed to the presence of gums. It is probable that this class of bodies is the source of the reducing sugars produced, but the amount of sugar or gum present in this extract is so small that it is no matter of great moment by what name we designate it.

§13. The reducing power of the hot water extract after the action of malt extract has been expressed as starch. The total amount extracted by the cold and hot water respectively is much less than one would expect, but it must be borne in mind that the hay or fodder had been previously extracted, we may say exhausted, with boiling 80 per cent. alcohol. The amounts extracted by these media are also much more nearly equal than one would expect, the cold water in a few instances actually dissolving more than the hot water and malt extract.

§14. The hydric chlorid used was a one per cent solution. The extraction of the hay or fodder with this reagent gave us more trouble than all other determinations combined. All of the work recorded in this bulletin was done in duplicate and if our results did not agree, the work was repeated until we found how to proceed in order to obtain concordant results.

§15. It is true that agreement of results may not be conclusive proof that the method used is the best one, or even that the work has been correctly done, but their disagreement, when obtained by the same method and under similar conditions, is conclusive of one of two things, either that the operations have been interrupted at different stages or that the method is wholly inadequate and an end point is not attainable. We found that the different hays and fodders resisted the action of this one per cent.

solution of hydric chlorid in very different degrees. In those cases in which the amount of xylan was high, we found that boiling for thirty minutes did not suffice for the accomplishment of our purpose, *i. e.*, to carry the action of the hydric chlorid to an end.

§16. In some fodders and dungs we found it necessary to boil them two, and in a few cases, even three times with separate portions of the acid in order to obtain results which agreed reasonably well. We found, too, that the inversion of this extract was much more difficult than of any of the others,—it being necessary to use ten c. c. conc. hydric chlorid and to digest in the water bath for two hours; this means at our altitude, a temperature of about 85° to possibly 90° C. in the solution, even though the water in the bath is kept boiling briskly. We found that this quantity of acid and time gave us the highest results, measured in terms of the reducing power, and usually a good agreement between the duplicates.

§17. The sodic hydrate used was also a one per cent. solution. The reducing power of this extract, after inversion, was, as a rule, very small. We observed in this connection that the reducing power of this extract was frequently higher in those cases in which we found it difficult to complete the extraction with hydrochloric acid than in others. I interpret this variation as suggesting that the small amount of reducing sugars found in the sodic hydrate extract may belong to the hydric chlorid extract rather than indicate the presence of a hexose sugar.

§18. The residue left after treatment with sodic hydrate was washed free from Na O H, dried, etc. It was next moistened with water and spread out on the inner surface of a small flask which was connected with a chlorin apparatus and allowed to stand for an hour after the flask had become entirely filled with the gas. It was then washed, boiled with dilute Na O H and subsequently with H_2 S O_3 and the residue finally dried and weighed as cellulose. The action of chlorin, etc., did not produce any reducing sugars, at least there were none present in the filtrate.

§19. In Bulletin 93, we have recorded our results in determining the coefficients of digestion of the groups, substances usually taken cognizance of in our ordinary fodder analyses, *i. e.*, Dry Matter, Ash, Fat, Protein and Nitrogen-free Extract; in the present bulletin, I intend to present the results of these same experiments using a different series of groups, or to give the coefficients of digestion for the alcoholic extract, cold water extract, hot water extract, one per cent. hydic chlorid extract, one per cent. sodic hydrate extract, chlorin extract, and lastly, of the cellulose or that portion which persistently resists the action of these reagents. In addition to the preceding coefficients, I shall give the coefficients of digestion

of those groups which yield the reducing sugars under the conditions already indicated and also of those complexes which yield furfurol on distillation with twelve per cent. hydric chlorid solution, but as I have sought to determine the distribution of these groups and complexes in the different extracts it will be quite impossible to bring the results within the compass of a single table. I will, therefore, be compelled to make two statements of the results which will supplement each other, but which cannot in any sense replace or contradict each other. I will also give the calorific values of the hays, dungs and of the residues yielded by the respective treatments in the case of the alfalfa, corn fodder and saltbush, these being the best for our purposes; timothy hay, sorghum and native hay not suiting so well. Our native hay is a mixture of such character that results obtained with it would be of little value except in a very general sense.

§20. The hays and fodders used in this work are the same as those used in Bulletin 93, in fact, that work was done largely for the purpose of obtaining data according to the conventional methods for the particular samples used n this study. The hays and fodders were intentionally chosen to represent both legumes and grasses grown and preserved under our Colorado conditions.

§21. The distribution of the nitrogen in these extracts appears from the results of the work recorded in Bulletin 39, to present some points of more than usual interest. For instance, we found that 27 per cent. of the total nitrogen in alfalfa hay was removed by extraction with boiling 80 per cent. alcohol and subsequent treatment with cold water. This nitrogen may have been contained in the coloring matters to a greater extent than in some other hays, but it is certainly not all contained in the chlorophyll and it is not probable that it is amid nitrogen for it exceeded the amount that we had previously found in alfalfa hay in this form. The advisability of making these nitrogen determinations is further indicated by the persistence with which some nitrogen remains with the crude fibre after boiling with 1.25 per cent. sodic hydrate solution. In the work referred to we found that 4.51 per cent. of the total nitrogen in alfalfa hay remained in the crude fibre, when it had been prepared in the usual way by boiling for thirty minutes with the 1.25 per cent. sodic hydrate solution. We shall see that this was not a chance result, but indicated a general fact and we shall further see that this statement is correct for the hays and fodders studied in this bulletin.

§22. The distribution of the ash in these various extracts has been wholly disregarded.

§23. The analysis of the dungs present, of course, the same questions that the conventional methods do in regard to the com-

pounds in which the nitrogen is contained, *i. e.*, whether it is contained in undigested portions of fodder or in fecal matter. The results obtained in this work in regard to the nitrogen, are open to the same questions that those of our ordinary analysis and possibly to even more serious ones, for we divide it up into six or seven portions instead of presenting it as the common constituent of a single class without raising any further questions.

§24. The samples of hays fed were of course the same throughout the experiments, so that one analysis represents the whole of any fodder fed and no questions can arise relative to this; concerning the orts and dungs, however, there might be a question. In Bulletin 93, we calculated the coefficient of digestion for each individual animal and took the average of the coefficients so found as the coefficients of digestion of the several hays and fodders. Owing to the tediousness of the work, we followed a different procedure in this case, *i. e.*, we made composite samples of the dungs, by taking the same aliquot part of the dung voided by the different sheep in each 24 hours during the time of the experiment and combining them into a composite sample. The sample of orts was prepared in a similar manner.

ANALYTICAL DATA—ALFALFA HAY.

§25. The following analyses have been brought together in order to present, succinctly as possible, all that our analyses tell us about the fodders and their digestibility.

The average coefficients of digestibility found for this particular alfalfa hay were for the dry matter 62.08, ash 57.67, fat 29.86, protein 72.54, fibre 49.93, and for the nitrogen-free extract 72.89. The general facts presented by the data concerning alfalfa pertain to all of the other fodders.

TABLE I.

ALFALFA HAY.

FODDER ANALYSIS.

ALFALFA HAY		FECES OF SHEEP NO. 6	
Moisture	7.75	Moisture	6.82
Ash	11.77	Ash	12.15
Ether Extract	1.62	Ether extract	3.12
Proteids	15.03	Proteids	10.86
Crude Fibre	30.28	Crude Fibre	40.34
Nitrogen-free extract	33.55	Nitrogen-free extract	26.83
	100.00		100.00

TABLE II.

ASH ANALYSIS.

ALFALFA		CORRESPONDING FECES*	
Percentage of ash in hay..	11.77	Percentage of ash in Feces..	12.15
Sand	8.524	Sand	12.682
Silicic acid	6.844	Silicic acid	8.676
Sulfuric acid	6.269	Sulfuric acid	2.037
Phosphoric acid	3.158	Phosphoric acid	7.629
Carbonic acid	17.399	Carbonic acid	21.081
Chlorin	6.801	Chlorin	0.666
Potassic oxid	27.271	Potassic oxid	3.207
Sodic oxid	4.287	Sodic oxid	1.733
Calcic oxid	14.736	Calcic oxid	29.590
Magnesic oxid	4.006	Magnesic oxid	7.719
Ferric oxid	1.428	Ferric oxid	1.440
Aluminic oxid	0.288	Aluminic oxid	0.879
Manganic oxid (br)	0.180	Manganic oxid (br)	0.330
Ignition	0.341	Ignition	2.481
	101.532		100.150
Oxygen, Equiv. to chlorin..	1.532	Oxygen Equiv. to Chlorin..	.150
	100.000		100.000

TABLE III.

ULTIMATE ANALYSIS.

ALFALFA HAY		CORRESPONDING FECES	
Carbon	43.517	Carbon	45.769
Hydrogen	5.868	Hydrogen	5.494
Nitrogen	2.405	Nitrogen	1.738
Sulfur	0.342	Sulfur	0.189
Chlorin	0.819	Chlorin	0.123
Phosphorus	0.162	Phosphorus	0.405
Potassium	2.665	Potassium	0.323
Sodium	0.374	Sodium	0.156
Calcium	1.239	Calcium	2.569
Magnesium	0.286	Magnesium	0.566
Oxygen plus the remaining ash constituents	42.323	Oxygen plus the remaining ash constituents	42.668
	100.000		100.000

§26. For good, clean, alfalfa hay the ratio of thoroughly air-dried feces to the hay consumed is one to two and seven-tenths or five and one-half pounds of hay eaten will correspond to just a trifle more than two pounds of feces.

§27. The silicic acid has not been taken into account in the preceding analyses because it is very uncertain how much of it is due to fluxing of the minerals constituting the dust and sand found in the ash.

§28. These data show the extent to which the potash is taken up by the animal system, the feces being very poor in this substance

*Sheep No. 6.

while the opposite is the case with the phosphoric acid and lime.

§29. The ultimate composition of the hay and feces does not appear to differ as much as one might expect, so far as the carbon, hydrogen and oxygen are concerned but an ultimate analysis of a mixture of such complex substances as we have to do with in these cases could scarcely be expected to show decided differences, still it shows that 61.6 per cent. of the carbon in the hay consumed, is digested. The feces show a higher percentage of carbon than the hay, which may indicate that the compounds having the higher carbon content are less readily attacked than those with less. These analyses further show that the hydrogen, nitrogen, sulfur, chlorin and the alkalies, particularly potassium, are very largely taken up from the fodder, while the calcium, magnesium and prosphorus are voided with the feces to a very large extent. This is strikingly the case in regard to phosphorus, for according to the ratio given for the hay consumed to the feces voided, 5½ : 2, it results that of 892 parts of phosphorus ingested by sheep, 810 parts are voided with the feces, which indicates a coefficient of digestion of 10.3 per cent. for the phosphorus consumed, which is quite small, averaging 1.31 grams per day, of which only 10.3 per cent. or 0.131 gram was appropriated by the animal. The potassium stands in strong contrast to this with a coefficient of 95.6 per cent. The following pages present some further considerations, based on different data.

§30. The following analyses are of an entirely different character and present a study of the same hay from another standpoint.

§31. The statement of the analyses is given so fully that no further explanation is needed in this place.

TABLE IV.

ANALYSIS OF ALFALFA HAY.

The percentages given in following analyses are computed on air-dried hay.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted...	27.177	27.818	27.50
Cold water, 24 hours digestion, extracted	8.535	8.785	8.66
Hot water and malt extracted... ...	4.790	3.950	4.37
Hydric chlorid, 1 per cent. sol., extracted	12.487	11.968	12.23
Sodic hydrate, 1 per cent. sol., extracted	15.341	17.046	16.19
Chlorin, etc., extracted....	8.372	9.155	8.76
Cellulose, residue	23.298	21.278	22.29
			100.00

SUGARS IN THE EXTRACTS.

Glucose in the alcoholic extract......	1.280	1.280	1.28
Sucrose in the alcoholic extract......	0.942	0.942	0.94
Gums, etc., in cold water extract.....	0.833	0.770	0.80
Starch in hot water and malt extract	1.267	1.260	1.26
Galactan, inverted by 1 per cent. HCl	2.960	2.770	2.87
Reducing power of the 1 per cent. Na O H extract	0.320	0.378	0.35

The average of two determinations of galactan made according to the official method was 2.89 per cent. It seems probable that the reducing power of the one per cent. HCl extract of alfalfa hay is wholly due to galactan, but only partly so in corn fodder and in native hay.

TABLE V.

ANALYSIS OF ALFALFA ORTS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	26.532	26.276	26.40
Cold water, 24 hrs. extracted........	8.580	8.559	8.57
Hot water and malt extracted.......	3.970	4.256	4.11
Hydric chlorid, 1 per cent. sol. extracted	11.687	11.863	11.78
Sodic hydrate, 1 per cent. sol. extracted	16.637	14.885	15.76
Treatment with chlorin, etc., extracted	8.519	9.853	9.19
Cellulose remaining	24.074	24.308	24.19
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.........	1.25	1.25	1.25
Sucrose in alcoholic extract.........	1.67	1.45	1.56
Gums in cold water extract.........	0.47	0.38	0.43
Starch in hot water extract.........	0.94	0.97	0.96
Galactan	3.96	4.45	4.21
Reducing power of sodic hydrate extract	0.70	0.97	0.80

TABLE VI.

ANALYSIS OF DUNG OF SHEEP FED ON ALFALFA HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted...	19.107	19.363	19.24
Cold water, 24 hrs. digestion, extracted	4.912	4.872	4.89
Hot water and malt extracted.......	3.635	3.349	3.49
Hydric chlorid, 1 per cent. sol., extracted	13.580	12.457	13.02
Sodic hydrate, 1 per cent. sol., extracted	12.796	15.166	13.98
Treatment with chlorin, etc., extracted	19.711	15.091	17.40
Cellulose remaining................	26.259	29.702	27.98
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.........	None	None	None
Sucrose in alcoholic extract.........	None	None	None
Gums in cold water extract.........	0.40	0.52	0.46
Starch in hot water and malt extract	0.21	0.21	0.21
Galactan in hydric chlorid extract..	1.37	0.98	1.18
Reducing power of sodic hydrate extract	1.57	1.30	1.44

TABLE VII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	3671.4	260.5	3410.9	890.9	2520.0	73.88
Total cold water extract....	1157.2	84.6	1072.6	228.4	846.2	78.89
Total hot water malt extract	583.6	40.6	543.0	161.6	381.4	70.24
Total hydochloric acid ext..	1630.9	116.2	1514.7	602.9	911.8	60.20
Total sodic hydrate extract	2161.6	155.5	2006.1	647.3	1358.8	67.72
Total chlorin etc., extract..	1170.6	90.7	1079.9	805.7	274.2	25.39
Total cellulose	2976.1	238.7	2737.4	1295.6	1441.8	52.67
Total dry mater	13351.4	986.8	12364.6	4630.4	7734.2	62.55

§32. The average coefficient of digestion of the dry matter in this hay obtained by the usual method was found to be 62.05. It is given as 63.95 on page 23 of Bulletin 93, but this is a mistake It should be 62.05.

TABLE VIII.

COEFFICIENTS OF DIGESTION OF THE CARBOHYDRATES IN ALFALFA HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
In alcoholic extract, glucose	170.9	12.3	158.6	00.0	158.6	100.00
In alcoholic extract, sucrose	125.5	15.4	110.1	00.0	110.1	100.00
In cold water ext., gums, etc.	106.8	4.2	102.6	19.4	83.2	81.09
In hot water malt ext. starch	164.2	9.5	154.7	9.7	145.0	93.73
In 1 p. c. hydrochloric acid extract, Galactan	381.9	41.5	340.4	54.6	285.8	83.96
In 1 p. c. sodic hydrate extract, (Hexose?)........	46.7	7.9	38.8	66.7	Excess —27.9	
In chlorin, etc., extract, this extract showed no reducing power.						
Cellulose residue after chlorin, etc., treatment						52.67

§33. In the preceding table, it will be noticed that the amount of reducing sugar found in the one per cent. sodic hydrate extract for the dung exceeds the amount found for the extract of the hay by a very considerable amount, 71.91 per cent.

§34. At first, I thought that the small amount of reducing sugar found in the solution obtained by boiling the hays or fodders with the one per cent. solution of sodium hydrate, was due to imperfect extraction by the hydrochloric acid or perhaps owed its origin to complexes which had been attacked by the hydrochloric acid and thereby rendered soluble in the sodic hydrate, but the relatively large amount extracted from the dung by this reagent, for we find the same excessive amount in the dungs corresponding to each of the six fodders suggests that it is not an accident due to the incompleteness of the action of the hydrochloric acid but that it is due rather to the presence of some compound which effectively resists the action of the hydrochloric acid but which is soluble in sodic hydrate and is either hydrolized by this agent or is made susceptible to the action of the hydrochloric acid subsequently used as the hydrolytic agent. If this were the indication of even a duplicate analysis of the dung corresponding to one of the fodders, one would certainly be justified in doubting its sufficiency as the basis of any inference, but it is not simply an accidental agreement of duplicate results, obtained in the analysis of a single sample of dung, but is the result of duplicates made on the dungs corresponding to six fodders which differ materially from one another. This difference between the fodders and the corresponding dungs may be due to changes produced in the fodders during their passage through the alimentary tract or to excrementitious matter proper. It seems probable that it is the latter.

§35. In regard to the reducing sugar produced by the action of the dilute hydric chlorid, I have in the case of the alfalfa attributed it to the presence of galactan because the agreement between the determination of mucic acid and the reducing power of the inverted solution was good; in the other cases I have used the term xylan as a general term for the pentosans hydrolized by the dilute hydic chlorid. Mucic acid determinations made on the samples of corn fodder and native hay indicate the presence of some galactan but its quantity is much less than the total reducing power, so it is probable that both galactan and xylan are present, but I have used the term xylan in all cases except in that of alfalfa.

§36. The total reducing power of the extract yielded to one per cent. sodic hydrate solution by alfalfa hay corresponds to 38.8 grams, whereas the reducing power of the extract yielded by the feces under the same treatment corresponds to 66.7 grams or 1.7 times as much. Whatever the source of this reducing power may be it is evidently much more abundant in the extract of the dung voided than in the hay consumed. It is probable that the excessive reducing power of the sodic hydrate extract of the dung over that of the hay is due to its action on fecal matter and not on the undigested rem-

nants of the hay. This excessive reducng power of the sodic hydrate extract of the dung over that of the hay is not an accident or attributable to inaccurate work, for it is uniformly the case with all of the dungs corresponding to the six fodders used.

§37. This result is similar to that obtained for the coefficient of digestion for the ether extract in the first series of experiments made on the digestion of alfalfa hay in which the amount of ether extract obtained from the feces was more than double the amount consumed. In this case, I attributed this excess to the solubility of fecal matter only after I had canvassed every other apparent explanation, because it was observed in one series of experiments only and was not observed in the case of any other fodder than the alfalfa. If other experimenters have met with such striking results, they have rejected them, as I was tempted to do, for the simple reason that others have done this work in the same way and the recorded results agreed in showing that my results were, to say the least, very exceptional. In this case, however, I have a series of six very different fodders and they agree in showing that, in this respect, there is a marked difference between the fodders and the feces of the animals feeding on them.

PENTOSANS.

§38. There are certain complexes existing in the fodders which when subjected to distillation with hydrochloric acid yield furfurol. In this work, I have considered this furfurol as such and have endeavored to determine its coefficients of digestibility for the various extracts.

§39. In Bulletin 39, we found the total amount of furfurol calculated as xylan yielded by alfalfa, to range for the first cutting from 9.44 to 14.42 per cent.; for the second cutting, hay grown at Rocky Ford, 12.34 per cent. The average found for the cutting of 1894 was 11.44 per cent.; for 1896, 11.48 and the average for all of the determinations made on samples covering the two years was 11.48 per cent.

§40. The furfurol found in the hay used in these experiments, was 8.16 or 13.38 xylan; in the orts 9.95 per cent.; in the feces 12.69 per cent. xylan. There were fed 1786.4 grams of xylan. The orts contained 98.19 grams and the feces 587.6; accordingly 1100.6 grams of xylan had been digested or the coefficient of digestion for the total xylan was 65.12. The corresponding amounts of furfurol are, in the hay fed 1089.5 grams, in the orts 59.9 grams, in the feces 318.9 grams, digestion coefficient 65.18.

§41. We determined the furfurol in the residue after the extraction and not in the evaporated extract for the same reason that we determined the extracts themselves by difference, *i. e.,* be-

cause we found a deficiency of about two per cent. on evaporating the extracts to dryness.

TABLE IX.

FURFUROL FOUND IN ALFALFA HAY, ORTS AND THE FECES AND IN THE RESIDUE AFTER TREATMENT WITH THE VARIOUS SOLVENTS.

	Alfalfa hay Per cent.	Alfalfa orts Per cent.	Feces Per cent.
Original Hay	8.160	6.068	7.742
Residue after 80 per cent. alcohol	7.078	5.367	7.638
Residue after cold water	6.494	5.322	Same
Residue after hot water	5.736	5.122	6.940
Residue after 1% hydric chlorid	4.220	3.765	Same
Residue after 1 per cent. sodic hydrate	2.586	2.131	3.778
Residue after chlorin, etc.	1.919	2.080	1.394

TABLE X.

THE COEFFICIENTS OF DIGESTION FOR FURFUROL IN THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Furfurol in alcoholic extract	144.50	6.90	137.60	4.80	132.80	96.51
Furfurol in cold water ext	77.98	0.40	77.58	0.00	77.58	100.00
Furfurol in hot water ext	101.20	2.00	99.20	32.30	66.90	67.44
Furfurol in hydrochloric acid extract	202.40	13.40	189.00	0.00	189.00	100.00
Furfurol in sodic hydrate ext	218.20	16.10	202.10	146.90	55.20	27 81
Furfurol in chlorin, etc., ext	89.05	10.50	88.55	110.39	—21.84	....
Furfurol in residue, cellulose	256.20	20.50	235.70	64.54	171.16	72.62
	1089.53	59.80	1029.73	358.90	670.83	65.15

§42. The treatment with boiling one per cent. hydric chlorid aims at the removal of easily hydrolized substances which might yield fufurol on distillation with the stronger, 12 per cent., acid. This treatment removes considerable quantities of furfurol yielding substances from the hay which apears to be wholly digestible for we find none in the feces. On the other hand, the hydric chlorid, one per cent. solution, removes hydrolyzable substances from the feces corresponding to 1.03 per cent. of galactan. The one per cent. hydric chlorid solution removes from the hay 1.52 per cent. of furfurol and contains reducing sugars equal to 3.01 per cent. of galactan which is probably the source of the reducing sugar, as the hay yields when treated with hydric nitrate, sp. gr. 1.15, according to the official method, mucic acid corresponding to 2.86 per cent, galactan, so it seems probable that both pentose and hexose sugars are represented in the composition of the hay.

§43. I have elsewhere noted the fact that in making duplicate determinations of this reducing power, it was difficult to obtain agreement in the results and that in some fodders, we had to repeat the treatment as many as three times to get even a fair agreement. I interpret this as indicating a radical difference in the character of the compounds in the different fodders which are attacked by this reagent.

METHOXYL GROUP.

§44. At the time this work was done no tests, so far as I knew, had been made to prove whether this group existed in ordinary plants. Recently, however, it has been shown that certain woods, not known to contain quinine or related alkaloids, yield methyl iodid on distillation with strong hydriodic acid showing the presence of compounds containing the methoxyl group.

§45. The presence of aromatic compounds in the urine of herbivores and the fact of the general prevalence of alkaloidal compounds in plants, some of which contain the methoxyl group, suggested the probability of the presence of this group in the fodders. I accordingly attempted its determination, using the original Zeisel method.

§46. I did not determine this group in the orts, for both the amount of the orts and the percentage of this group present being small, no great error is introduced by the omission, besides my chief object was to establish the presence or absence of the group in the case of each fodder and obtain, if possible, an idea of the amount of these compounds appropriated by the animal, an approximate coefficient of digestion. I did not hope to accomplish more than this.

§47. The duplicate, and in some cases, triplicate determinations, agreed fairly well. The largest difference in twelve sets of duplicates, including also some triplicates, was less than one-half of one per cent. We checked our work using quinine, a commercial article, obtaining a fair agreement in our determination, but the results were a little lower than required by theory, which leads me to infer that my results are too low rather than too high.

METHOXYL GROUP IN ALFALFA HAY FED AND FECES VOIDED.

	I Per cent.	II Per cent.	Av. Per cent.
Alfalfa Hay	1.18	1.23	1.21
Dung, sheep fed alfalfa............	2.46	2.31	2.39

§48. The hay consumed was 12,364.8 grams containing 148.38 grams of the methoxyl group; the feces weighed 4,630.5 grams and contained 110.7 grams of methoxyl, giving us a digestion coefficient of 25.42 for this group.

§49. I will anticipate a general result which will be evident when the determinations of this group in all the samples have been given, *i. e.*, that it is present in hays made from grasses and leguminous plants, also in corn fodder, sorghum and the saltbush, *Atriplex argentea*, being most abundant in the last named plant; further that the percentage of this group present in the dung is approximately twice that in the hay or fodder, except in the case of the saltbush in which it is only one and one-half times as much as in the saltbush itself.

AMID NITROGEN IN ALFALFA HAY.

§50. In calculating the proteids we have multiplied the total nitrogen by 6.25 consequently our product is too high, as more or less of the nitrogen is present in the form of amids, compounds containing a higher percentage of nitrogen and, consequently, having a factor less than 6.25, if for example, the nitrogen were present as asparagine, its factor would be 4.7.

§51. In the following statement I have given the proteid equivalent to the amids. I have made no attempt to divide the nitrogen compounds further than into the two groups, proteids and amids.

§52. The amid nitrogen found in samples of alfalfa hay cut at half bloom is as follows, 0.372, 0.350, 0.614; average is 0.444 which is rather far removed from the maximum which is, however, the highest found in eleven samples. The amid nitrogen found in the alfalfa hay used in this series of experiments was 0.446 agreeing very well with the average found for the other samples cut in half bloom.

§53. The proteids in the alfalfa hay fed, corresponding to the amid nitrogen, amounted to 372.11 grams; in the orts 34.66 grams; consumed 337.45 grams; voided 62.23 grams; digested 275.22 grams, from which we obtain 81.55 for the coefficient of digestion for the amid nitrogen.

THE PROTEIDS REMOVED BY THE VARIOUS SOLVENTS AND THEIR COEFFICIENT OF DIGESTION.

§54. As the boiling 80 per cent alcohol removed practically all the coloring matters from the hays, I deemed it advisable to extract them with anhydrous ether and determine the nitrogen removed in this manner. I have assumed that the nitrogen thus removed is principally contained in the coloring matters. For this extraction, I use 30 grams of air-dried hay, macerated it with 150 c. c. of ether for 16 hours, and then subjected it to extraction in a soxhlet extractor for ten hours. Our air-dried hay carries from 5 to 7 per cent. of moisture. I have repeatedly compared the results

obtained by extracting air-dried hay with those obtained from the same hay dried in the water oven, also in hydrogen and have seldom found so large a variation that it was of any practical significance. The maximum amount of nitrogen found in the ether extracts of the three hays, alfalfa, timothy and native hay, was contained in the extract from the native hay which contained 0.007 per cent.; that from the timothy contained nitrogen equal to 0.0033 per cent. and that from the alfalfa 0.0032 per cent., calculated on the air-dried hay. The largest one of which corresponds to less than 0.05 per cent. of proteids.

§55. The weight of the dried ether extracts from these three hays varied from 0.5 to 0.75 grams from which it is evident that the coloring matters in these hays must be poor in nitrogen.

§56. If we assume that the nitrogen in these ether extracts is present as proteid nitrogen there would be in that from the native hay approximately 0.05 per cent., a quantity which we can disregard in ordinary work but this is twice as large as the amount found in either of the other two hays.

§57. In regard to the sulfur in alfalfa, the question has frequently suggested itself whether it belonged mostly to the proteids or whether it was present in combination, as sulfuric oxid, probably forming calcic sulfate. Wishing to answer this question in connection with the proteids, we digested a quantity of hay with dilute hydrochloric acid and washed it thoroughly. The sulfuric acid was then precipitated as baric sulfate and weighed after purification. The sulfur present in the hay as sulfuric acid amounted to 0.68 per cent. The total sulfuric acid estimated from that found in the ash, allowing a loss of two per cent. in incineration, was 0.94, leaving sulfur equivalent to 0.26 per cent. of sulfuric acid as proteid sulfur.

§58. Corn fodder treated in the same manner did not show the presence of any sulfuric acid and the sulfur is probably present as proteid sulfur and not in the form of sulfates.

§59. In the following statements, the proteids, respectively the nitrogen calculated as proteids, soluble in 80 per cent. alcohol included the nitrogen soluble in the ether which, as we have just seen, is a very small amount, not more than 0.05 per cent.

§60. The coefficients of digestion for the proteids contained in the various extracts of alfalfa hay:—

TABLE XI.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS DISSOLVED OUT OF ALFALFA HAY BY THE VARIOUS SOLVENTS.*

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in boiling 80 per cent. alcohol	640.88	46.47	594.41	108.82	485.59	81.69
Proteids soluble in cold water	90.79	26.05	64.74	42.60	22.14	34.20
Proteids soluble in hot water and malt	134.85	9.87	124.98	68.53	56.45	45.17
Proteids soluble in 1 per ct. hydric chlorid	126.84	1.18	125.66	50.47	75.19	59.84
Proteids soluble in 1 per ct. sodic hydrate	937.28	75.58	851.70	154.20	697.50	81.89
Proteids soluble in chlorin, sodic hydrate and sulfurous acid	45.40	5.92	39.48	50.01	(—10.53)	——
Proteids remaining in the cellulose	17.36	1.28	16.08	13.43	2.65	16.48
			1817.05	488.06	1328.99	72.92

§61. The coefficients of digestion found for the proteids by the usual method, and given on page 23, Bulletin 93, are for sheep No. 4, 73.68 per cent.; sheep No. 5, 73.58 per cent.; sheep No. 6, 70.36 per cent.; the average is 72.54 per cent. The coefficient found by calculating it from the sum of the respective extracts of the hay, and dung is 72.92 per cent. actually in better agreement with the two higher coefficients found for sheep No. 4 and 5, than the result obtained for sheep No. 6.

§62. This coefficient, 72.92, would be slightly changed if we made a correction for the amid nitrogen found, but this is nearly correct for the total nitrogen. This statement applies to all the coefficients for the proteids.

THE CALORIFIC VALUE OF ALFALFA HAY.

§63. The calorific value of the hay was determined by means of the bomb calorimeter. By hay, we mean the air-dried hay as fed to the sheep; it contained 7.75 per cent. moisture and 11.77 per cent. ash. Its calorific value was 4,050 calories,† and that of the dung was 4,300 calories. The total hay consumed by the three sheep was 12,364.8 grams. The air-dried feces weighed 4,630.5 grams, which shows that the animals used 62.30 per cent. of the total heat value of the hay. I have assumed that the orts did not

*I have used the term proteids in this place to signify the product of the nitrogen multiplied by 6.25. This remark applies to all of the fodders. Everyone knows that this is conventional and does not mean that there is only one class of nitrogenous compounds present.

†The Calorie used throughout this Bulletin is the small calorie.

differ from the hay because I was compelled to, due to the fact that the orts had all been used for other determinations. The total amount of the orts was small.

§64. The total heat consumed as dry matter by the three sheep was 49,585,495 calories; the total heat value of the dry matter contained in the feces was 18,629,832 calories; there were accordingly 30,955,663 calories appropriated by the sheep, equivalent to 62.43 per cent. of the energy value of the hay. By appropriated I mean that the energy was taken up and either stored in the body or eliminated in some other way than through the alimentary tract as undigested food. The energy escaping in the exhalations, as well as that contained in the urine, is included in the term appropriated.

TABLE XII.

The dry hay gave the following extracts and residue:

	Per cent.
Soluble in boiling 80 per cent. alcohol	21.40
Soluble in cold water	9.38
Soluble in hot water and malt	4.73
Soluble in boiling 1 per cent. hydric chlorid	13.35
Soluble in boiling 1 per cent. sodic hydrate	17.54
Soluble in chlorin, etc.	9.45
Residue—cellulose—	24.15
	100.00

The distribution of the ash in these extracts was not determined.

TABLE XIII.

THE CALORIFIC VALUE OF THE HAY AND OF THE SEVERAL RESIDUES.

The calorific value of the dry hay	4363 calories
The calorific value of residue after extraction with 80 per cent. alcohol	4270 calories
The calorific value of residue after extraction with cold and hot water	4517 calories
The calorific value of residue after extraction with 1 per cent. hydric chlorid	4759 calories
The calorific value of residue after extraction with 1 per cent. sodic hydrate	4603 calories
The calorific value of residue after extraction with chlorin, etc.,	4210 calories

TABLE XIV.

Calories removed from alfalfa hay by the successive treatments.

One gram of hay yields to boiling 80 per cent. alcohol	1007 calories
One gram of hay yields to cold and hot water with malt	443 calories
One gram of hay yields to boiling 1 per cent. hydric chlorid	480 calories
One gram of hay yields to boiling 1 per cent. sodic hydrate	887 calories
One gram of hay yields to treatment with chlorin, etc.	527 calories
One gram of hay yields a residue, cellulose	1017 calories
	4363 calories

TABLE XV.

CALORIFIC VALUE OF THE RESPECTIVE EXTRACTS OF ALFALFA HAY.

One gram of the alcoholic extract gives	4706 calories
One gram of the cold water, hot water and malt extract gives	3140 calories
One gram of the 1 per cent. hydric chlorid extract gives	3596 calories
One gram of the 1 per cent. sodic hydrate extract gives	5063 calories
One gram of the chlorin, etc. extract gives	5598 calories
One gram of the residue, cellulose, gives	4210 calories

TABLE XVI.

THE DRY FECES (ALFALFA HAY) GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

	Per cent.
Soluble in boiling 80 per cent. alcohol	13.405
Soluble in cold water	5.243
Soluble in hot water and malt	3.742
Soluble in boiling 1 per cent. hydric chlorid	13.961
Soluble in boiling 1 per cent. sodic hydrate	14.980
Soluble in chlorin, sodic hydrate and sulfurous acid	18.657
Residue, cellulose	30.012
	100.00

TABLE XVII.

THE CALORIFIC VALUE OF THE FECES (ALFALFA) AND THE VARIOUS RESIDUES.

The calorific value of the dry feces	4525 calories
The calorific value of the residue after extraction with 80 per cent. alcohol	4339 calories
The calorific of the residue after extraction with cold and hot water and malt	4373 calories
The calorific value of the residue after extraction with 1 per cent. hydric chlorid	4441 calories
The calorific value of the residue after extraction with 1 per sodic hydrate	4886 calories
The calorific value of the residue after extraction with chlorin, etc.	4294 calories

TABLE XVIII.

THE CALORIFIC VALUE REMOVED FROM THE FECES (ALFALFA HAY) BY THE SUCCESSIVE TREATMENTS.

One gram of dry feces yields to boiling 80 per cent alcohol	769 calories
One gram of dry feces yields to cold and hot water with aid of malt	362 calories
One gram of dry feces yields to boiling 1 per cent. hydric chlorid	567 calories
One gram of dry feces yields to boiling 1 per cent. sodic hydrate	449 calories
One gram of dry feces yields to chlorin, etc.	1090 calories
One gram of dry feces yields residue, cellulose	1288 calories

TABLE XIX.

THE CALORIFIC VALUE OF THE VARIOUS EXTRACTS OF THE FECES (ALFALFA HAY)

One gram of the alcoholic extract gives ....5739 calories
One gram of the cold and hot water, etc., extract gives........4123 calories
One gram of the boiling 1 per cent. hydric chlorid gives.......4061 calories
One gram of the boiling 1 per cent. sodic hydrate gives.........2997 calories
One gram of the chlorin, etc., extract gives..................5842 calories
One gram of the residue, cellulose, gives.....................4294 calories

TABLE XX.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Heat Units Consumed	Heat Units Voided	Heat Units Appro.	Coefficient
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extract*	5,074,240	1,599,724	3,474,516	68.51
One per cent. hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
One per cent. sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,045,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

§65. The coefficients of digestibility of the heat values of the various extracts show the same general features exhibited by the preceding tables, showing , in particular, the high value of the portion soluble in 80 per cent. alcohol which furnishes the largest portion by weight of dry substance digested—over one-third of the total nitrogen digested and one-third of the total heat units appropriated. The sodic hydrate extract furnished, in the case of alfalfa the largest amount of nitrogen, one-half more than the alcoholic extract, less dry matter than either the cellulose or the alcoholic extract and one-fifth less heat than the alcoholic extract.

§66. The values of the extracts, measured by the heat furnished, stand as follows for alfalfa :—Alcoholic extract, 11 millions heat units; sodic hydrate extract, 8 millions; the insoluble portion of the fodder, the cellulose, 6 millions of heat units.

§67. This order does not hold good for the other fodders examined in this manner. The alcoholic extract and the cellulose constitute two of the three most important portions of the fodder, but the hydric chlorid extract stands above the sodic hydrate as a source of heat in the corn fodder.

TIMOTHY HAY.

§68. The timothy hay used was the best that we could obtain in the open market and was grown in the mountains.

§69. Though the hay appeared to be of excellent quality, the sheep did not do well on it, one sheep gained one-half pound in five

*The aqueous extract includes all that was dissolved out by cold water, 24 hours digestion, boiling with water for one hour and subsequently treating with malt extract.

days, the other two together lost one and a half pounds, leaving a net loss of one pound for the three sheep in five days. This is in strong contrast with the results obtained with the alfalfa and corn fodder. The sheep fed alfalfa all gained. The total gain for the three sheep was nine pounds in five days; those fed on corn fodder also all gained, the total gain in five days being three and one-half pounds, so we have 9 and 3 ½ pounds gain respectively for the alfalfa and corn fodder, against a net loss of one pound for the timothy hay. The coefficient of digestion for the dry matter in the alfalfa hay found by the ordinary method of determining it was 62.05, and by considering the extracts individually it was 62.55. In the case of the timothy hay, we obtained in the ordinary manner 51.03, in the manner here pursued 51.10, an excellent agreement in both cases with a difference of 11 per cent.in these coefficients, that of the alfalfa being the higer. The sheep consumed, however, 11,265 grams of dry matter, as alfalfa hay, leaving almost no orts and only 8,223 grams of dry matter as timothy hay, leaving 4,233 grams of orts.

TABLE XXI.

ANALYTICAL DATA. TIMOTHY HAY.

Proximate Analysis.

TIMOTHY HAY		CORRESPONDING FECES Sheep No. 1	
Moisture	6.49	Moisture	6.79
Ash	9.37	Ash	7.84
Ether extract	2.99	Ether extract	2.28
Proteids	5.62	Proteids	5.92
Crude fibre	31.54	Crude fibre	37.26
Nitrogen-free extract	43.99	Nitrogen-free extract	39.91
	100.00		100.00

TABLE XXII.

ANALYSIS OF THE ASH.

TIMOTHY HAY		CORRESPONDING FECES	
Sand	26.249	Sand	43.943
Silicic acid	11.506	Silicic acid	9.126
Sulfuric acid	3.033	Sulfuric acid	1.515
Phosphoric acid	4.239	Phosphoric acid	11.428
Carbonic acid	5.390	Carbonic acid	1.259
Clhorin	7.177	Chlorin	0.798
Potassic oxid	30.118	Potassic oxid	10.721
Sodic oxid	0.146	Sodic oxid	1.122
Calcic oxid	5.586	Calcic oxid	11.981
Magnesic oxid	2.685	Magnesic oxid	3.868
Ferric oxid	0.540	Ferric oxid and Aluminic oxid	1.171
Alumnic oxid	0.176		
Manganic oxid	0.370	Manganic oxid	0.189
Ignition	(4.357)	Ignition	3.000
	101.617		100.121
Oxygen equivalent to Chlorin	1.617	Oxygen equivalent to chlorin	.180
	100.000		99.941

TABLE XXIII.

ULTIMATE ANALYSIS.

TIMOTHY HAY		CORRESPONDING FECES	
Carbon	44.241	Carbon	46.362
Hydrogen	5.832	Hydrogen	6.186
Nitrogen	0.892	Nitrogen	0.954
Sulfur	0.104	Sulfur	0.143
Chlorin	0.506	Chlorin	0.133
Ash	9.370	Ash	7.840
Oxygen (approx.)	39.045	Oxygen (approx.)	38.382
	100.000		100.000

§70. The ash in this analysis, of course, represents the thoroughly oxidized, non-combustible portion of the plant containing a considerable portion of both the chlorin and sulfur. The chlorin and sulfur given above are the quantities contained in the air-dried hay as obtained by direct determination. The percentage of ash as given is too high by the amount of the chlorin and sulfur retained which is from 92 to 98 per cent. of the total sulfur and chlorin respectively, and also by the oxygen which the ash constituents may have taken up. The percentage of oxygen is, for these reasons, retention of chlorin and sulfur and the possible absorption of oxygen by the ash constituents, too low, for which reason, I have designated it as approximate only.

TABLE XXIV.

ANALYSIS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	21.307	20.931	21.12
Cold water in 24 hrs. extracted......	6.858	7.039	6.95
Hot water extracted	3.000	2.968	2.98
Hydric chlorid, 1 per cent. sol. extracted	19.740	20.717	20.23
Sodic hydrate, 1 per cent. sol. extracted	17.108	16.997	17.05
Chlorin, etc., extracted	5.548	5.872	5.71
Cellulose remaining	26.439	25.476	25.96
			100.00

SUGARS IN THE EXTRACTS

	I	II	Av.
Glucose in alcoholic extract.........	1.16	1.44	1.30
Sucrose in alcoholic extract.........	2.83	2.83	2.83
Gum in cold water extract..........	3.12	3.12	3.12
Starch in hot water extract.........	None	None	None
Reducing power calculated as Xylan in hydric chlorid extract	15.77	Lost	15.77
Reducing power calculated as Xylan in sodic hydrate extract..........	0.83		0.83

TABLE XXV.

ANALYSIS OF ORTS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	22.952	23.194	23.07
Cold water in 24 hrs. extracted......	4.034	4.447	4.24
Hot water extracted	2.895	2.461	2.68
Hydric chlorid, 1 per cent. sol. extracted	19.552	19.826	19.68
Sodic hydrate, 1 per cent. sol. extracted	Lost	14.680	14.68
Chlorin, etc., extracted		8.530	8.53
Cellulose remaining		27.120	27.12
			100.000

SUGARS IN THE EXTRACTS

	I	II	Av.
Glucose in alcoholic extract.........	2.48	2.43	2.46
Sucrose in alcoholic extract.........	3.29	3.37	3.33
Gum in cold water extract..........	1.82	2.03	1.93
Starch in hot water extract.........	None	None	None
Xylan in hydric chlorid extract......	14.32	15.39	14.86
Xylan in sodic hydrate extract......	Lost	1.31	1.31

TABLE XXVI.

ANALYSIS OF FECES OF SHEEP FED ON TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	16.592	15.512	16.05
Cold water in 24 hrs. extracted......	2.840	2.818	2.83
Hot water extracted	3.255	3.288	3.27
Hydric chlorid, 1 per cent. sol. extracted	16.230	16.802	16.52
Sodic hydrate, 1 per cent. sol. extracted	16.893	19.226	18.06
Chlorin, etc., extracted	14.272	11.563	12.92
Cellulose remaining	29.918	30.792	30.35
			100.00

SUGARS IN THE EXTRACTS

	I	II	Av.
Glucose in alcoholic extract.........	None	None	None
Sucrose in alcoholic extract.........	None	None	None
Gum in cold water extract..........	0.20	0.0	0.10
Starch in hot water extract.........	None	None	None
Xylan in hydric chlorid extract......	7.91	9.44	8.68
Xylan in sodic hydrate extract......	2.25	2.06	2.15

TABLE XXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	3813.0	1036.5	1776.5	691.4	1085.1	61.08
Total cold water extract....	925.6	190.5	816.1	121.9	694.2	85.06
Total hot water and malt ext.	397.8	120.4	277.4	140.9	136.5	49.21
Total hydrochloric acid 1% extract	2694.4	884.2	1810.2	711.6	1098.6	60.69
Total sodic hydrate (1 per per cent.) extract.......	2270.9	659.8	1511.1	777.9	733.2	48.52
Total chlorin, etc., extract..	760.6	383.0	377.6	551.5	Excess —173.9	——
Total cellulose, residue, ...	3457.7	1218.3	2239.3	1307.4	931.9	41.61
Total	13320.0	4492.7	8808.2	4307.6	4500.6	51.10

Average coefficient of digestion for dry matter given page 29, Bulletin No. 93, 51.03.

TABLE XXVIII.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN TIMOTHY HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
In the alcoholic extract:						
Glucose	173.2	110.5	62.7	0.0	6.27	100.00
Sucrose	377.0	149.6	227.4	0.0	227.4	100.00
In the cold water extract, Gums, etc.	415.6	86.7	328.9	4.3	324.6	98.69
In the hot water and malt extract, (starch)	0.0	0.0	0.0	0.0	0.0	——
In the 1 per cent. hydrochloric acid (Xylan) extract ...	2100.6	667.6	1433.0	373.9	1059.1	72.23
In the 1 per cent. sodic hydrate (Xylan) extract	110.5	58.9	51.6	92.6	Excess 41.0	——

§71. The furfurol in timothy hay was found to be 12.17 per cent. and there was accordingly 1,621.0 grams fed. The orts contained 11.60 per cent. equal to 521.2 grams and the feces contained 12.73 per cent., equal to 548.4 grams. This gives us 50.12 per cent. for the coefficient of digestion of the furfurol.

§72. I have used the furfurol instead of the complexes yielding it as we know quite certainly that there are probably several compounds present which may yield furfurol. Our coefficient, 50.12, shows no more than that one-half of the furfurol has been digested. If the complexes from which this is derived yield the same amounts of furfurol and are broken down with equal readiness, in the alimentary tract of the animal and by the distillation with the twelve per cent. acid, we would be justified in assum-

ing that one-half of the furfurol yielding substances are available as food for the ruminant. This is probably not far from the facts in the case, but it will be seen from the following table that we have very good reasons for doubting whether the complexes are equally attacked as we assume in making this statement.

TABLE XXIX.

FURFUROL IN THE VARIOUS EXTRACTS OF TIMOTHY HAY AND COEFFICIENTS OF DIGESTION.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	86.6	42.7	43.7	13.4	30.5	69.47
Cold water	122.7	17.5	105.2	30.5	74.7	71.07
Hot water	26.6	9.0	17.6	34.5	(—16.9)	———
Hydric Chlorid	542.7	186.9	355.8	263.1	92.7	32.80
Sodic hydrate	456.8	151.0	305.8	270.5	35.3	11.54
Clorin	129.2	39.1	90.1	1.3	88.8	98.54
Cellulose	271.7	74.6	197.1	98.2	98.9	50.12
			1115.5	711.2	404.3	36.24

§73. The results in this table are unsatisfactory, but we repeated a number of the determinations and found no error. The discrepancy between the coefficient found by summing up the amounts in the individual extracts of the hay, orts and dung and that found by determining the furfurol in the hay, orts and dung themselves is altogether too great, but the amount digested in either case is comparatively small and large differences result from comparatively small errors in the work. The general coefficient found was 50.12.

COEFFICIENT OF DIGESTION OF THE METHOXYL GROUP IN TIMOTHY HAY.

§74. The orts, as in the case of the alfalfa, have been considered as containing the same percentage of methoxyl as the hay, which is probably not correct, but this error can be neglected as the difficulties of the determination do not permit of great accuracy at the best. The hay consumed contained 124.20 grams; there was voided 103.70 grams; digested 20.5 grams, or 16.50 per cent.

DIGESTIBILITY OF THE AMIDS IN TIMOTHY HAY.

§75. The amid nitrogen found in the timothy hay used, corresponded to 0.99 per cent. of proteids, or 0.168 per cent. nitrogen and that found for the orts was almost identical, 0.994 per cent.; in the feces we found none. According to this the amid nitrogen is wholly digestible.

§76. This result is aparently not in accord with the results given under the next caption, but we found no amid nitrogen in the

feces of sheep fed on timothy hay, native hay, corn fodder or saltbush, that is to say, we found no nitrogen in these samples which was not precipitated by cupric hydrate.

TABLE XXX.

COEFFICIENTS OF DIGESTION OF THE PROTEIDS IN THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	187.81	35.04	152.77	24.12	128.65	82.30
Proteids soluble in cold and hot water	82.58	41.78	40.80	53.41	(—12.61)	....
Proteids soluble in 1% hydric chlorid	98.57	33.25	65.32	42.65	22.67	34.71
Proteids soluble in 1% sodic hydrate	350.31	126.69	223.62	92.61	136.01	58.59
Proteids soluble in chlorin	13.23	10.78	2.45	37.48	(—35.03)	....
Proteids in residue, cellulose	9.32	2.70	6.62	6.89	(—0.27)	....
Total	741.82	250.24	491.58	257.16	234.42	47.69

The general coefficients of digestibility found for the three individual sheep were 47.73, 41.06 and 41.27. Average 43.35.

CALORIES CONSUMED AND VOIDED.

§77. We find the calorific value of dry timothy hay to be 4,414 and 4,417, an average of 4,415 plus; the orts gave 4,392 and the feces 4,709 calories.

§78. The dry matter fed contained 54,979,995 calories; the orts contained 18,586,944 calories and the feces 18,986,688 calories, which indicates the use of 47.83 per cent. of the heat energy of the fodder, or 17,406,363 calories.

§79. This timothy hay proved to be a poor fodder for sheep when fed alone. Two of the sheep lost weight and the third one gained one-half pound between the two weighings.

§80. We did not carry our calorimetric work further with timothy hay for the reason that this hay has been made the subject of study by others. Quite an exhaustive study of it is to be found in the Report of the Pennsylvania State College for the year 1903 and 1904.

NATIVE HAY.

§81. This hay is made up of a mixture of grasses and represents a fodder which is prized by many as an excellent one. The mixture of grasses varies greatly even in hay from the same farm. The results obtained in experiments with this hay are therefore applicable to other samples of it in a general way only, and it is for

this reason that we have not determined the heat value of the residues, obtained by extracting the hay with the various solvents adopted in this work.

TABLE XXXI.

ANALYTICAL DATA FOR NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES Sheep No. 6.	
Moisture	5.13	Moisture	5.96
Ash	10.64	Ash	12.41
Ether extract	3.13	Ether extract	5.02
Proteids	6.98	Proteids	5.48
Crude fibre	31.38	Crude fibre	29.29
Nitrogen-free extract	42.74	Nitrogen-free extract	41.84
	100.00		100.00

TABLE XXXII.

ANALYSIS OF ASH IN NATIVE HAY.

ASH OF NATIVE HAY		ASH OF CORRESPONDING FECES	
Carbon	Heavy trace	Carbon	———
Sand	3.375		
Silicic acid	54.736	Sand and Silicic acid	73.913
Sulfuric acid	1.521	Sulfuric acid	0.884
Phosphoric acid	2.133	Phosphoric acid	3.156
Carbonic acid	4.871	Carbonic acid	2.849
Chlorin	4.878	Chlorin	0.347
Potassic oxid	17.786	Potassic oxid	5.373
Sodic oxid	0.640	Sodic oxid	0.845
Calcic oxid	6.180	Calcic oxid	7.587
Magnesic oxid	2.016	Magnesic oxid	1.477
Ferric oxid	0.685	Ferric oxid	0.280
Aluminic oxid	0.273	Aluminic oxid	0.266
Manganic oxid	0.132	Manganic oxid	0.210
Ignition	1.719	Ignition	(2.891)
	100.945		100.078
Oxygen equivalent to chlorin	1.099	Oxygen equivalent to chlorin	0.078
	99.846		100.000

TABLE XXXIII.

ULTIMATE ANALYSIS OF NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES	
Carbon	43.814	Carbon	45.328
Hydrogen	5.792	Hydrogen	5.935
Nitrogen	0.996	Nitrogen	0.919
Sulfur	0.116	Sulfur	0.109
Chlorin	0.673	Chlorin	0.073
Ash	10.640	Ash	12.410
Oxygen, (approx.)	27.969	Oxygen, (approx.)	25.226
	100.000		100.000

§82. The ash analysis of this hay shows a very high percentage of silicic acid. It is a well known fact that the ash of some of the grasses contain a large amount of silica, but this ash is as high or even a little higher than the superior limit usually found. This ash, when evaporated to dryness with hydric chlorid and subsequently treated with water, leaves a felt-like mass of silicic acid which is made up of quadrangular plates with irregular margins. If a stem of this hay be treated with hydric nitrate and potassic chlorate, to destroy the tissues and remove the soluble salts, and then be burned, one can obtain a beautiful skeleton of silica showing the outlines of the epidermal cells and the stomata. The total ash amounts to a little over one-tenth of the weight of the hay, and over one-half of this is silicic acid. The skeleton thus obtained seems to show that the stem is completely sheathed in a siliceous covering. The leaves also furnish skeletons, but these differ considerably in their details from the skeletons of the stems. The silica, however, seems quite abundant in the leaves, almost as much so as in the stems. This blue stem feels harsh to the touch, not so much so, perhaps, as the sedges, but the skeletal silica seems to be even more abundant in the blue stem than in the sedges.

§83. The coefficient of digestion found for this ash, 42.52, seems to be very high, too high in fact, but the separation of the silicic acid and sand in the ash of the feces was particularly difficult.

TABLE XXXIV.

PROXIMATE ANALYSIS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	21.469	21.537	21.50
Cold water, in 24 hrs., extracted......	5.917	5.813	5.87
Hot water extracted	2.975	2.726	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.544	21.049	20.80
Sodic hydrate, 1 per cent. sol., extracted	16.485	16.816	16.64
Chlorin, etc., extracted	5.586	4.868	5.23
Cellulose, residue	27.024	27.191	27.11
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.38*	1.38	1.38
Sucrose in alcoholic extract	2.89	2.89	2.89
Gums in cold water extract	2.50	2.50	2.50
Starch in hot water extract	1.10	1.12	1.11
Reducing power expressed as Xylan, hydric chlorid extract............	12.53	12.53	12.53
Reducing power expressed as Xylan, sodic hydrate extract............	Trace	Trace	Trace.

*We experienced more trouble than usual with this sample, so I have used averages of several pairs. The results are only approximately correct.

TABLE XXXV.

ANALYSIS OF ORTS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	23.377	24.256	23.82
Cold water, in 24 hrs., extracted.....	5.899	5.197	5.55
Hot water extracted	2.999	2.701	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.062	20.066	20.06
Sodic hydrate, 1 per cent. sol., extracted	16.917	16.922	16.92
Chlorin, etc., extracted	7.359	7.772	7.57
Cellulose, residue	23.387	23.086	23.23
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract	1.54*		1.54
Sucrose in alcoholic extract	1.72		1.72
Gums in cold water extract	2.83		2.83
Starch in hot water extract	1.12		1.12
Xylan in hydric chlorid extract......	12.53		12.53
Xylan(?) in sodic hydrate extract....	1.28		1.28

TABLE XXXVI.

DUNG OF SHEEP FED ON NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	17.430	17.928	17.68
Cold water, in 24 hrs., extracted.....	3.090	3.251	3.17
Hot water extracted	3.351	3.880	3.62
Hydric chlorid, 1 per cent. sol. extracted	15.538	15,230	15.38
Sodic hydrate, 1 per cent. sol., extracted	23.011	22.387	22.70
Chlorin, etc., extracted	9.288	9.078	9.18
Cellulose, residue	28.292	28.246	28.27
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract	None	None	None
Sucrose in alcoholic extract	None	None	None
Gums, etc., in cold water extract.....	Trace	Trace	Trace
Starch in hot water extract	None	None	None
Xylan in hydric chlorid extract......	10.13	9.07	9.60
Xylan(?) in sodic hydrate extract...	2.22	2.28	2.25

*This analysis, like that of the hay, was exceedingly unsatisfactory, though done in duplicate and repeated by two different operators.

TABLE XXXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	2834.1	618.7	2215.4	918.2	1297.2	58.55
Total cold water extract...	773.8	144.2	629.6	164.6	465.0	73.86
Total hot water and malt extract	375.7	74.0	301.7	188.0	113.7	37.69
Total hydric chlorid extract	2741.9	521.0	2220.9	798.7	1422.2	64.04
Total sodic hydrate extract	2193.5	439.5	1754.0	1178.9	575.1	32.79
Total chlorin, etc., extract.	689.4	196.6	492.8	476.7	16.1	3.28
Residue, cellulose	3573.6	603.3	2970.3	1468.1	1502.2	50.57
	13182.0	2597.3	10584.7	5193.2	5391.5	50.94

Average coefficient given for dry matter, Bulletin 93, page 32, 50.53.

TABLE XXXVIII.

COEFFICIENT OF DIGESTION FOR THE CARBOHYDRATES IN NATIVE HAYS, AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract.	181.9	40.0	141.9	0.0	141.9	100.00
Sucrose in alcohol extract..	381.0	44.7	336.3	0.0	336.3	100.00
Gums in cold water extract	329.6	73.5	256.1	Trace	256.1	100.00
Starch in hot water and Malt extract	146.3	29.1	117.2	0.0	117.2	100.00
Xylan in hydric chlorid ext.	1651.7	325.4	1326.3	496.3	830.0	62.58
Xylan(?) in sodic hydrate extract	147.6	29.1	.118.5	116.8	1.7	1.43
	2838.1	541.8	2296.3	613.1	1683.2	73.30

TABLE XXXIX.

COEFFICIENTS OF DIGESTION OF THE FURFUROL IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	107.6	51.3	56.3	21.4	34.9	61.91
Cold water .... / Hot water .... }	87.3	40.2	47.1	43.9	3.2	6.79
Hydric chlorid, 1% Sol.....	711.6	102.7	608.9	240.7	368.2	44.04
Sodic hydrate, 1% Sol......	359.7	51.6	308.1	178.2	129.9	42.16
Chlorin	126.9	17.6	109.3	121.9	-12.6	....
Cellulose	269.0	49.9	219.1	54.9	164.2	74.94
	1662.1	313.3	1348.8	661.0	687.8	50.99

§84. The coefficient of digestion found by calculating the furfurol in the hay fed, subtracting that contained in the orts, etc.,

is 50.63, which is in good agreement with that obtained by taking the sum of the separate extracts.

TABLE XL.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	230.69	47.53	183.16	66.47	116.69	63.71
Proteids soluble in cold water and hot water and malt	69.86	18.96	50.90	35.83	15.07	29.61
Proteids soluble in 1% hydric chlorid	97.55	23.12	74.43	27.52	46.91	63.03
Proteids soluble in 1% sodic hydrate	383.60	59.48	324.12	129.82	194.30	58.58
Proteids soluble in chlorin,	29.00	4.93	24.07	27.01	—2.94	——
Proteids remaining in the cellulose	10.55	2.08	8.47	11.95	—3.48	——
	821.25	156.10	665.15	298.60	366.55	55.11

§85. The average coefficients of digestion found for the proteids in native hay, using three sheep, was 62.33, Colorado Experiment Station Bulletin No. 93, page 32.

HEAT VALUE OF NATIVE HAY.

§86. The energy was found to be equal to 4,349 calories for the dry hay and that of the dried feces was found to be 4,579 calories. The calorific value of the fodder consumed was 46,034,165 calories, that of the feces 23,778,747 calories; accordingly the animals appropriated 22,255,418 calories, or 48.34 per cent. of the total energy.

§87. The heat values or energy of the different extracts were not determined because, as stated in the description of this hay, it is made up of a mixture of grasses, sedges, etc., which varies so that this sample cannot be taken as representative except in a general way.

AMID NITROGEN.

§88. The proteids corresponding to the amid nitrogen in native hay amounted to 0.513 per cent., but we were unable to find any in the feces, consequently we infer that they were wholly digestible. The better way to put this is that the quantity of amid nitrogen is so small that, as a fodder constituent, it is wholly negligible.

METHOXYL GROUP IN NATIVE HAY.

§89. This group is present in the hay to the extent of 1.795 per cent., and in the feces to the extent of 2.764 per cent. The hay

consumed was 10,585 grams, and the feces voided 5,193 grams, which gives us a coefficient of 23.47 for the digestibility of this group in the hay.

§90. The results obtained in feeding this hay were fairly good, the net result being a gain of three and one-half pounds during the five days between the weighings. The dry matter voided in the feces was almost one-half of that consumed, and the coefficients of digestion were found to be comparatively low. This hay, designated as native hay, commands a high price and is held in high esteem, particularly for horses.

§91. In this experiment no grain or other fodder than the hay was fed. I wished to study the hay and not to determine an advantageous ration, of which it should be a part.

§92. If we compare the data furnished by the results obtained with alfalfa and those obtained in the case of the native hay, we observe very great differences. In the first place, the alfalfa is evidently a more palatable food to sheep than this hay or timothy. There was fed of the native hay, 13,182 grams, the sheep left 2,596 grams; of the alfalfa, 13,350 grams, of which 987 grams were left; of the timothy, 13,320 grams, of which 4,493 grams were left. These hays were all cut in order to induce the sheep to eat it up clean as possible. Sheep prefer, for instance, the leaves of alfalfa to the stems, and I wished to force them to eat the stems as well as the leaves.

TABLE XLI.

THE AMOUNT OF THE RESPECTIVE EXTRACTS DIGESTED AND THEIR COEFFICIENTS OF DIGESTION.

	Native Hay Grams digested	Coefficients	Alfalfa Hay Grams digested	Coefficients
Alcohol, 80%	1297.	58.55	2520.	68.64
Cold water	465.	73.86	846.	78.89
Hot water	114.	37.69	381.	70.24
Hydric chlorid	1422.	64.04	912.	60.20
Sodic hydrate	575.	32.79	1359.	67.72
Chlorin	16.	3.28	274.	25.39
Cellulose	1502.	50.57	1442.	52.67

§93. In regard to the relative amounts of the extracted matter digested and corresponding coefficients, we observe that much larger amounts of those substances dissolved out by the eighty per cent. alcohol, cold and hot water, the latter with addition of malt exextract, were digested in the case of the alfalfa than in that of the native hay, and the coefficients of digestion are materially higher. The reverse is the case with those substances dissolved out by the one per cent. hydric chlorid, the quantity digested, as well as the

coefficient of digestion, being higher in the case of native hay than in that of the alfalfa. The amount of digestible matter removed from alfalfa by the one per cent. solution of sodic hydrate is greater, about 2⅓ times, than that removed from the native hay. The matter removed by chlorin, etc., is neither considerable in quantity, nor does it appear to be very digestible. The amounts of cellulose digested were approximately the same in the two cases, as are also the coefficients of digestion.

§94. The most important fact to be kept in mind in this comparison is that the same sheep when fed these hays made a uniform gain of three pounds in five days on the alfalfa, or a net gain of nine pounds, whereas two gained one-half pound each and one two and a half pounds in five days, a net gain of three and one-half pounds, when fed the native hay. It may be futile to seek an explanation of these results in the analytical data, but it is the purpose of this bulletin to present the latter as fully as we are at present able to, in order to see whether this may in any way be possible. An examination of the amounts of the various extracts digested and their coefficients of digestion would lead us, possibly justly so, to attach great importance to the alcoholic and sodic hydrate extracts, especially as the latter solvent is supposed to remove the principal portion of the nitrogenous compounds to which we are accustomed to attach great value.

§95. It may be that these two extracts, those obtained by alcohol and sodic hydrate, respectively, do stand in some immediate relation to the respective values of the two hays, but some facts to be presented subsequently in connection with another fodder, while not showing that the above inference is wrong, will lead us to hesitate in drawing conclusions too freely.

§96. The substances removed by chlorination, including subsequent treatment with sodic hydrate and sulfurous acid, was 16 grams in the case of the native hay, 274 grams in that of the alfalfa, the former having a coefficient of 3.28 per cent., and the latter 25.39 per cent., both very low. The residue, which I have designated as cellulose though I know it is not pure, amounts to 1,502 grams in the native hay and 1,442 grams in the alfalfa, much more nearly equal than one would expect. The same, too, being true of the coefficients of digestion, as we find 50.57 for the cellulose from the native hay and 52.67 for that from the alfalfa.

§97. If we study the distribution of the nitrogen in the various extracts and the coefficients of digeston obtained, we find even greater differences, because we deal with smaller numbers and there is, too, a marked difference in the quantity of this element in the two fodders, the alfalfa being much the richer, containing almost 24 times as much nitrogen.

TABLE XLII.

The following figures represent grams of proteids (N. x 6.25).

DIGESTIBILITY OF THE PROTEIDS IN THE RESPECTIVE EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcohol, 80%	115.0	62.98	486.0	81.77
Cold water, hot water and malt..	16.0	32.34	63.0	25.91
Hydric chlorid, 1%	57.0	67.34	132.0	72.38
Sodic hydrate, 1%	184.0	58.63	649.0	80.89
Chlorin, etc.	——	——	12.0	30.19
Cellulose	——	——	3.0	16.48

§98. We have not only a very much larger amount of proteids in the alfalfa, but also very much higher coefficients of digestion. Both hays show that sodic hydrate and alcohol are the two solvents removing the nitrogen. The hydric chlorid standing third in the list, removing one-half as much from the native hay and almost one-third as much from the alfalfa as the alcohol.

§99. In this connection the amid nitrogen should probably be considered; at least, the relative amounts in the hays should be given. The alfalfa consumed contained amid nitrogen corresponding to 337.45 grams proteids, with a coefficient of digestion of 81.55. The native hay contained an amount corresponding to 54.29 grams, the whole of which was digested, as no amid nitrogen was found in the feces.

§100. If we next compare the sugars contained in these two hays, we will find still other differences.

TABLE XLIII.

DIGESTIBILITY OF THE CARBOHYDRATES, MEASURED BY THE REDUCING POWER OF THE INVERTED EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcoholic extract, Sucrose.......	142.0	100.00	159.0	100.00
Alcoholic extract, Glucose.......	336.0	100.00	110.0	100.00
Cold water, gums, etc	256.0	100.00	83.0	81.09
Hot water and malt, starch......	117.0	100.00	145.0	93.73
Hydric chlorid, 1% invert. sugar	830.0	62.58	286.0	83.96
Sodic hydrate, 1% invert. sugar, very minute quantity.				

§101. Except in the case of sucrose and starch, we find that the native hay contains more of these substances, or complexes yielding them, than the alfalfa. The most marked instance is the reducing power yielded by the hay on being treated with the one per cent. hydric chlorid, whereby hydrolysis effected the production of sugar equal to 1,326 grams of xylan, of which 830 grams were digested, whereas, in the alfalfa, the same treatment produced 340

grams galactan, of which 286 grams or 83.96 per cent. were digested. The differences here are quite marked and, so far as the quantity digested is concerned, apparently in favor of the native hay.

§102. If we, in like manner, compare the results obtained by determining the furfurol, we will observe that other differences are strongly indicated.

TABLE XLIV.

FURFUROL DIGESTED.

	Native Hay Grams digested	Native Hay Coefficients	Alfalfa Hay Grams digested	Alfalfa Hay Coefficients
Alcoholic extract	35.0	61.99	133.0	96.51
Cold water	3.0	6.79	78.0	100.00
Hot water and malt			67.0	67.44
Hydric chlorid, 1%	268.0	44.04	189.0	100.00
Sodic hydrate, 1%	130.0	42.16	55.0	27.81
Chlorin, sodic hydrate, etc.	....	.....	....	.....
Cellulose	164.0	74.94	171.0	72.62

§103. We observe that the furfurol yielding substances in these two fodders must be very different. Those removed by alcohol, water and hydric chlorid from the alfalfa hay having a much higher coefficient of digestion than those dissolved out of the native hay, while the furfurol yielding bodies removed by the one per cent. sodic hydrate from the alfalfa show a low coefficient of digestion, much lower even than the corresponding substances in the native hay. When we come to the portion that I have designated cellulose, we find the amount of furfurol digested in the two cases and also the coefficients of digestion very close together, so that this factor would apparently fall out of our consideration. The same is indicated by the amount of cellulose digested in these two cases, the three sheep having digested 1,441 grams cellulose fed as alfalfa and 1,502 grams fed as native hay. As pure cellulose yields from 2 to 2.5 per cent. of furfurol, and we obtained for the alfalfa cellulose 1.919 and for that from the native hay, 2.041 per cent. furfurol, the two products are probably almost pure cellulose, and the above results in regard to the cellulose are such as we should expect.

§104. In the case of the native hay, we find that the coefficients of digestion for the furfurol are low, except in the case of that yielded by the cellulose. The most marked features are the deportment of those compounds yielding furfurol, but which are soluble in one per cent. solutions of hydric chlorid or sodic hydrate. Such substances removed from alfalfa by one per cent. hydric chlorid seem to be wholly digestible, while those removed by the sodic hydrate are only slightly digestible. The alfalfa consumed contained substances soluble in the one per cent. hydric chlorid, which

yielded 189 grams furfurol, while those soluble in one per cent. sodic hydrate yielded 202 grams of furfurol. Those substances present in the native hay soluble in one per cent hydric chlorid yielded a total of 609 grams of furfurol, of which 44.04 per cent. was digestible; those soluble in one per cent. sodic hydrate yielded 308 grams of furfurol, of which 42.16 per cent. was digestible. Another very marked difference between these fodders is the solubility of the substances yielding furfurol in the different media, the furfurol yielded by the cellulose not being considered in the following statements. Hydric chlorid removes from the native hay almost exactly one-half of the furfurol—coefficient 44.04—while it removes about one-quarter of it from the alfalfa, coefficient 100. Sodic hydrate removes from the native hay one-quarter of the furfurol, coefficient 42.16; from the alfalfa one-quarter, with a coefficient of digestibility of 27.81.

§105. The one per cent. sodic hydrate solution seems to remove very considerable amounts of material which is capable of yielding furfurol from both of these fodders, but we were unable to obtain more than minute quantities of reducing sugars in the inverted extracts, which is contrary to what we would expect if this furfurol is derived from pentosans.

§106. The heat values of these two hays, alfalfa and native hay, show more directly, probably, than any other factors their relative values. We find that the animals appropriated 30,519,751 calories when fed on alfalfa, and 22,255,418 calories when fed on the native hay. The same sheep were used in these two experiments, both made under favorable conditions, so that the questions of individualty, etc., are removed as far as far as possible. The net result was a gain of 9 pounds in the one case, alfalfa, and three and one-half pounds in the other, native hay.

§107. Other sheep were used in the experiment with timothy hay, but the conditions were as favorable as we could make them. The energy consumed was 17,406,363 calories, and the result was a net loss of one pound.

CORN FODDER.

§108. The fodder used was in good condition. The stalks were rather heavy for sheep feeding and the amount refused by them was, on this account, rather large. The corn was a variety of dent and had been grown in drills in which the seed had been thinly sown. The fodder was cut in lengths not exceeding one-half inch before feeding. The sheep ate it readily, but refused the heavier stocks, nor could we induce them to eat this portion by grinding it. Each of the three sheep used in this experiment gained weight while being fed on it. No other food was fed in connection with it. The

coefficients of digestion for this fodder were found to be quite good, excepting that that for the proteids was much below the average, as we found 36.04 as the coefficient of digestibility for these substances, whereas the average found by other experimentors is 56.1. The total proteids in this fodder is slightly above the average. I know of no reason for the low coefficient, but I have elsewhere observed that the coefficients obtained by us are apt to be below those found by others, due, probably, to the conditions under which our fodders are preserved.

TABLE XLV.

ANALYTICAL DATA FOR CORN FODDER.

FODDER ANALYSIS.

CORN FODDER.		CORRESPONDING FECES. Sheep No. 1.	
Moisture	8.21	Moisture	6.73
Ash	9.53	Ash	12.63
Ether extract	1.55	Ether extract	1.12
Proteids	4.62	Proteids	7.16
Crude fibre	29.85	Crude fibre	30.16
Nitrogen-free extract	46.24	Nitrogen-free extract	42.20
	100.00		100.00

TABLE XLVI.

ANALYSIS OF THE ASH.

CORN FODDER.		CORRESPONDING FECES.	
Sand	13.048	Sand	23.796
Silicic acid	19.812	Silicic acid	38.867
Sulfuric acid	1.313	Sulfuric acid	1.063
Phosphoric acid	5.199	Phosphoric acid	5.158
Carbonic acid	10.319	Carbonic acid	0.060
Chlorin	3.495	Chlorin	0.571
Potassic oxid	28.366	Potassic oxid	3.626
Sodic oxid	2.603	Sodic oxid	0.759
Calcic oxid	6.090	Calcic oxid	10.625
Magnesic oxid	4.501	Magnesic oxid	6.500
Ferric oxid	1.530	Ferric oxid	1.909
Aluminic oxid	0.851	Aluminic oxid	1.343
Manganic oxid	0.260	Manganic oxid	0.170
Ignition	(3.401)	Ignition	5.685
	100.788		100.132
Oxygen equivalent to Cl.	0.788	Oxygen equivalent to Cl.	0.103
	100.000		100.029

TABLE XLVII.

ULTIMATE ANALYSIS.

CORN FODDER.		CORRESPONDING FECES.	
Carbon	42.661	Carbon	42.754
Hydrogen	5.892	Hydrogen	5.494
Nitrogen	0.739	Nitrogen	1.145
Sulfur	0.099	Sulfur	0.133
Chlorin	0.342	Chlorin	0.152
Ash	9.530	Ash	12.630
Oxygen (approx.)	40.737	Oxygen (approx.)	37.692
	100.000		100.000

§109. The chlorin and sulfur determinations were made on the fodder and not calculated from the ash. The oxygen percentage is only approximate, as the ash contains most of the sulfur and chlorin and probably oxygen taken up during the burning, and these elements enter the analysis in part, at least twice.

§110. The ratio of the air-dried feces to the weight of air-dried fodder consumed is 1:2.33; in the case of alfalfa it is 1:2.7. The portion of the corn fodder left by the sheep amounted to 24 per cent. of the fodder, while the portion of alfalfa left amounted to 7.38 per cent. This difference is considerable when considered in pounds only, but when the character of the two fodders is taken into consideration, the proportion of the corn fodder consumed seems quite favorable. The ratio of the leaves in this fodder to the stems was 2:1, which is not very different from the ratio of leaves to stems in the alfalfa plant, but the corn stalk is very different from the alfalfa stem. Sheep will not eat the alfalfa stems when they are coarse; this is probably due to the hardness of the stems, but, in the case of the corn stalks, they will not eat them even when they have been ground. The results show that only about 10 per cent. or even less of the corn stalks was eaten when cut in lengths of from ¼ to ½ inch. The fodder had been cut close to the ground, so that the whole of the plant was represented in the fodder.

§111. It was hoped that the elementary analyses of the fodders might show some differences suggestive of the wide differences in their actual feeding values, but the range in the ultimate composition of both the fodders and the feces shows that they are of but little value for the purposes of this study, as they show nothing more, that we can interpret, than the fodder analysis.

TABLE XLVIII.

CORN FODDER.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	29.243	29.985	29.614
Cold water, 24 hours, extracted.....	4.350	4.827	4.589
Hot water and malt extracted......	3.881	2.603	3.241
Hydric chlorid, 1% sol. extracted....	19.550	20.244	19.897
Sodic Hydrate, 1% sol. extracted.....	13.891	13.692	13.792
Chlorin, etc., extracted	3.075	4.020	3.547
Cellulose	26.010	24.630	25.320
			100.00

SUGARS IN THE EXTRACTS.

	I	II	Av.
Glucose in alcoholic extract.........	5.24	5.29	5.26
Sucrose in alcoholic extract.........	4.44	4.09	4.27
Gums in cold water extract.........	0.58	0.45	0.52
Starch in hot water extract.........	None	None	None
Xylan* in hydric chlorid extract.....	12.07	10.88**	12.07
Xylan in sodic hydrate extract......	0.72	0.63	0.63

TABLE XLIX.

CORN FODDER ORTS.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol............	28.429	27.978	28.20
Cold water, 24 hours...............	2.538	3.379	2.96
Hot water	2.657	1.985	2.32
Hydric chlorid 1% sol.	20.149	20.584	20.37
Sodic hydrate, 1% sol.	14.590	15.443	15.02
Chlorin, etc.	3.626	3.684	3.66
Cellulose	28.011	26.947	27.48
			100.00

SUGARS IN THE EXTRACTS.

	I	II	Av.
Glucose in alcoholic extract.........	8.48	8.79	8.64
Sucrose in alcoholic extract.........	2.35	2.49	2.42
Gums in cold water extract.........	0.47	0.47	0.47
Starch in hot water extract.........	None	None	None
Xylan in hydric chlorid extract†.....	16.32	17.02	16.67
Xylan in sodic hydrate extract......	0.86	0.73	0.80

*There is some galactan present, in two trials we obtained 0.680 and 0.706%. Other trials did not agree in quantity but all showed presence of galactan. Galactan is easily hydrolyzed. This extract is not. The feces also gave a slight precipitate for mucic acid.

**Rejected, inversion incomplete.

†According to the mucic acid determination, there is a small amount of galactan present, but the 16.32% of sugar present is so large that I have calculated it all as Xylan.

TABLE L.

CORN FODDER FECES.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	16.71	16.27	16.50
Cold water, 24 hours, extracted.....	4.38	4.66	4.53
Hot water and malt extracted......	3.70	3.31	3.51
Hydric chlorid, 1% sol. extracted....	13.49	14.99	14.24
Sodic Hydrate, 1% sol. extracted.....	23.55	Lost	23.55
Chlorin, etc., extracted	11.12		11.12
Cellulose	26.55		26.55
			100.00

SUGARS IN THE EXTRACTS.

	I	II	Av.
Glucose in alcoholic extract.........	None	None	None
Sucrose in alcoholic extract.........	None	None	None
Gums in cold water extract.........	0.36	0.36	0.36
Starch in hot water extract.........	None	None	None
Xylan in hydric chlorid extract......	2.23	3.23	2.73
Xylan in sodic hydrate extract......	2.44	Lost	2.44

TABLE LI.

CORN FODDER—COEFFICIENTS OF DIGESTION OF THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcoholic extract	3461.4	737.2	2424.2	635.4	1788.8	73.79
Cold water extract.......	536.4	77.4	459.0	174.4	284.6	54.16
Hot water and malt ext...	378.8	60.6	318.2	135.2	183.0	54.37
Hydric chlorid, 1% extract.	2325.7	532.5	1793.2	548.4	1244.8	69.42
Sodic hydrate, 1% extract.	1612.1	392.7	1219.4	877.1	342.3	36.27
Chlorin, etc.	414.1	95.8	318.3	431.7	(—113.4)	
Cellulose	2959.5	718.4	2241.1	1030.9	1210.2	54.00
			8773.41	3833.1	4940.3	56.31

The general coefficient of digestion for the dry matter in corn fodder was found to be 56.66 per cent.

TABLE LII.

CARBOHYDRATES IN CORN FODDER AND THEIR COEFFICIENTS OF DIGESTIBILITY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose	656.9	225.9	431.0	0.0	431.0	100.00
Sucrose	499.1	58.6	440.5	0.0	440.5	100.00
Gums, etc.	60.8	12.3	48.5	13.8	34.7	71.56
Starch	0.0	0.0	0.0	0.0	0.0	——
Xylan, 1% hydric chlorid..	1410.8	435.8	975.0	105.1	869.9	89.22
Xylan(?) 1% sodic hydrate	73.6	20.9	52.7	94.0	(-41.3)	——
Cellulose	2959.5	718.4	2241.1	1030.9	1210.9	54.00

TABLE LIII.

FURFUROL FOUND IN CORN FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Cornfodder Per cent.	Orts Per cent.	Feces Per cent.
Original	11.476	10.625	10.997
Residue after treatment with 80% alcohol	10.792	10.530	10.894
Residue after treatment with cold water	10.768	same	same
Residue after treatment with hot water and malt	10.394	same	same
Residue after treatment with 1% hydric chlorid	5.342	5.841	7.536
Residue after treatment with 1% sodic hydrate	2.636	2.655	3.350
Residue after treatment with chlorin, etc., Cellulose	1.799	1.649	Not det.

TABLE LIV.

COEFFICIENT OF DIGESTION OF FURFUROL IN CORN AND THE PORTION DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.*	Consumed.	Voided.	Digested.	Coef.
Corn fodder	1341.4	277.8	1063.6	423.5	640.1	60.20
Soluble in 80% alcohol	80.0	2.5	77.5	4.0	73.5	94.80
Soluble in cold water	2.8**	——	2.8	0.0	2.8	100.00
Soluble in hot water and malt	43.7	——	43.7	0.0	43.7	100.00
Soluble in 1% hydric chlorid	590.3	122.6	467.7	125.5	342.2	73.17
Soluble in 1% sodic hydrate	316.3	80.3	236.0	160.9	75.1	31.82
Soluble in chlorin, etc.	97.8	26.3	71.5	129.0	62.3	32.57
Remaining in the cellulose	162.9	43.1	119.8			
			1019.2		479.8	47.07

METHOXYL GROUP IN CORN FODDER.

§112. The average percentage of this group found in the fodder was 1.445, and in the feces 2.033. In discussing this group under the subject of alfalfa, I stated that the results were probably rather low, basing this judgment on the check results obtained on a commercial sample of quinine. This observation applies to all of the samples and particularly, perhaps, to this case, as the amount found in the feces is the lowest in the series.

§113. The assumption that the orts and fodder were so nearly alike that no material error is made by taking them as the same is probably wrong in this case, for the orts were nothing other than corn stalks, which were so hard that the sheep did not eat them. They consisted essentially of the hard parts of the stalk and pith.

*These orts consisted wholly of pieces of stalks too hard for the sheep to eat.

**This figure has, as will readily be understood, no value, but it is the result that we obtained.

§114. The amount of this group, methoxyl, consumed was 129.67 grams, that voided was 78.27 grams, digested 51.40 grams, percentage digested 39.64.

AMID NITROGEN IN CORN FODDER.

§115. The total amid nitrogen found was very small, that found in the fodder was 0.077 per cent., equal to 0.481 per cent. of proteids; that found in the orts was 0.045 per cent., equal to 0.281 per cent. of proteids. We found none in the feces. The total is very small, but it is evident that we have to attribute to it a coefficient of digestion of 100.00.

TABLE LV.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF CORN FODDER.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	248.96	33.20	215.76	74.46	141.30	65.49
Cold water	32.73	1.83	30.90	25.85	5.05	16.30
Hot water and malt....	26.89	3.40	23.49	21.22	2.27	9.66
1% hydric chlorid	79.48	9.41	70.07	42.44	27.63	39.43
1% sodic hydrate	115.71	16.73	98.98	110.72	(—11.74)	——
Chlorin, sodic hydrate and sulfurous acid ..	30.39	1.57	28.82	15.43	13.39	46.46
Remaining in cellulose..	5.85	1.05	4.80	4.24	0.56	11.67
	540.01	67.19	472.82	294.36	178.46	37.74

§116. The coefficients found for the three sheep were 37.18, 37.49, 33.45; average 36.04 per cent.

THE CALORIFIC VALUE OF CORN FODDER AND ITS VARIOUS EXTRACTS.

§117 The calorific value of the dry corn fodder was found to be 4,244 calories, and the total heat units fed amounted to 45,533,876; the total value of the feces was 15,258,816 calories; the total heat value of the orts was 10,850,880 calories; the sheep therefore appropriated 19,424,180 calories, or 56 per cent. of that consumed.

§118. The sheep gained weight, 3½ pounds, during the five days that the test lasted. The gain was for the different sheep 2, 1 and ½ pounds, respectively. The number of heat units appropriated by the sheep is less than in the case of the native hay, 22,255,418 calories, while the gain in weight is the same; the coefficient of digestion, however, is higher, it being in the case of the native hay 48.34 per cent., and in the corn fodder 56 per cent. In timothy hay it was 47.83 per cent., and the heat units appropriated by the sheep were 17,406,363. One of the sheep gained and two lost, resulting in a net loss of one pound for the three sheep:

Timothy hay, heat units appropriated, 17,406,363, loss 1.0 pounds.
Corn fodder, heat units appropriated, 19,424,180, gain 3½ pounds.
Native hay, heat units appropriated, 22,255,418, gain 3½ pounds.

The percentages of the heat units thus used by the sheep are 47.83, 56.00 and 48.34.

TABLE LVI.

The dry corn fodder gave the following extracts and residue:

	Per cent.
Soluble in 80% alcohol	23.32
Soluble in cold water	5.00
Soluble in hot water and malt	3.54
Soluble in 1% hydric chlorid	21.68
Soluble in 1% sodic hydrate	15.03
Soluble in Chlorin, etc.	3.86
Residue, Cellulose	27.57
	100.00

§119. The distribution of the ash in these extracts was not determined and, consequently, no correction has been made on account of it.

TABLE LVII.

The calorific values of the dry fodder and the respective residues were as follows:

	Calories.
The dry fodder	4244
Residue after extraction with 80% alcohol	4250
Residue after extraction with cold water Residue after extraction with hot water and malt	4405
Residue after extraction with 1% hydric chlorid	4459
Residue after extraction with 1% sodic hydrate	4201
Residue after extraction with chlorin, etc.	4134

TABLE LVIII.

CALORIES REMOVED BY THE SUCCESSIVE TREATMENTS.

One gram of corn fodder yields to 80% alcohol	985 calories
One gram of corn fodder yields to cold water One gram of corn fodder yields to hot water and malt	257 calories
One gram of corn fodder yields to 1% hydric chlorid	930 calories
One gram of corn fodder yields to 1% sodic hydrate	752 calories
One gram of corn fodder yields to chlorin, etc.	180 calories

TABLE LIX.

CALORIFIC VALUES OF THE EXTRACTS OF CORN FODDER.

One gram of alcoholic extract equals	4224 calories
One gram of cold water extract equals One gram of hot water and malt extract equals	3009 calories
One gram of 1% hydric chlorid extract equals	4290 calories
One gram of 1% sodic hydrate extract equals	5003 calories
One gram of chlorin, etc., extract equals	4665 calories
One gram of residue, cellulose, equals	4134 calories

TABLE LX.

The dry feces gave the following extracts and residue:

APPROXIMATE ANALYSIS OF THE DRY FECES.

	Per cent.
Soluble in 80% alcohol	10.48
Soluble in cold water	4.86
Soluble in hot water and malt	3.76
Soluble in 1% hydric chlorid	15.27
Soluble in 1% sodic hydrate	25.25
Soluble in chlorin, etc.	11.92
Residue, cellulose	28.46
	100.00

TABLE LXI.

The distribution of the ash was not determined.

THE CALORIFIC VALUES OF THE DRY FECES AND THE RESPECTIVE RESIDUES.

The calorific value of the dry feces equaled	4248 calories
Residue after extraction with 80% alcohol	4153 calories
Residue after extraction with cold water Residue after extraction with hot water and malt	4252 calories
Residue after extraction with 1% hydric chlorid	4126 calories
Residue after extraction with 1% sodic hydrate	*3889 calories
Residue after extraction with chlorin, etc	3714 calories

TABLE LXII.

CALORIES REMOVED FROM THE FECES (CORN FODDER) BY THE SUCCESSIVE TREATMENTS.

One gram of feces yields to hot 80% alcohol	530 calories
One gram of feces yields to cold and hot water and malt	236 calories
One gram of feces yields to 1% hydric chlorid	774 calories
One gram of feces yields to 1% sodic hydrate	1138 calories
One gram of feces yields to chlorin, etc.,	513 calories
One gram of feces yields a residue, cellulose	1057 calories
	4248 calories

TABLE LXIII.

CALORIFIC VALUES OF THE RESPECTIVE EXTRACTS OF THE FECES (CORN FODDER.)

One gram of the alcoholic extract equals	5057 calories
One gram of cold and hot water with malt equals	2738 calories
One gram of the 1% hydric chlorid extract equals	5069 calories
One gram of the 1% sodic hydrate extract equals	4507 calories
One gram of the chlorin, etc., extract equals	4304 calories
One gram of the residue, cellulose, equals	3714 calories

*We at first doubted this result, so another sample was started de novo and the determination repeated with the result that we obtained 3891 calories as the value of this residue.

TABLE LXIV.

COEFFICIENTS OF DIGESTION FOR THE FUEL VALUES OF THE VARIOUS EXTRACTS OF CORN FODDER.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
One per cent. hydric chlorid ext.	7,691,970	2,774,812	4,914,158	63.88
One per cent. sodic hydrate ext.	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract..........	1,482,734	1,859,328	(-376,594)	....
Residue or cellulose	9,264,294	3,829,138	5,435,160	58.67

ALFALFA AND CORN FODDER COMPARED FROM THE STANDPOINT OF THEIR CALORIMETRIC RELATIONS.

§120. The two fodders first chosen for a complete study were alfalfa and corn fodder. In making this choice, I considered the fact that alfalfa is, beyond all question, our best fodder and, after it, for general all round purposes, corn fodder, probably stands next. Timothy is grown in considerable quantities in some sections of the state, but it is too limited in supply, and too high in price to be thought of as a general fodder, either by itself or for the purpose of balancing an alfalfa ration, unless it be for horses. Timothy has further been studied, and from this standpoint would have been, in part at least, a repetition of other work. Our native hay is a very much better fodder than timothy hay, but the supply of it is limited, the price is high, and its composition is variable, *i. e.*, the grasses, rushes and sedges forming it vary with localities and seasons. I chose corn fodder because it can be produced cheaply in large quantities over a large territory and because the results of feeding indicate that it is as good a fodder as the native hay and a very much better one than timothy hay. I was, in short, guided by the consideration of the utility of the respective fodders. It would have been a mistake to do so to the exclusion of other fodders, as my object has really not been to study good, acceptable fodders, but to discover, if possible, the reasons why one fodder is better than another, why one is good and another poor. While the difference between the values of corn fodder and alfalfa is considerable, it is not wide enough to give the best opportunity for presenting such a study with thoroughly satisfactory results. We will find larger differences when we come to the study of the saltbush, *Atriplex argentea*, which is an exceedingly poor fodder.

§121. There are very salient and interesting contrasts between these two fodders, alfalfa and the saltbush, *Atriplex argentea*, which I may digress to state briefly. The sheep fed on alfalfa gained nine pounds; those fed on saltbush lost eight and one-half pounds in five days. It is true that the sheep to which alfalfa was

fed digested a larger amount of dry matter than those receiving saltbush, but not so much more as the difference of 17½ pounds of flesh would apparently indicate. The sheep receiving alfalfa digested 7,246 grams of dry matter, containing 1,315 grams of proteids, 3,274 grams of nitrogen-free extract and 1,875 grams of crude fibre; those receiving saltbush digested 7,051 grams of dry matter, containing 1,116 grams of proteids; 3,011 grams of nitrogen-free extract and 342 grams of crude fibre. The mineral matter contained in the saltbush and digested was very large, 2,315 grams against 779 grams digested with the alfalfa. These are the differences, total dry matter, 195 grams; crude proteids, 199 grams; nitrogen-free extract, 263 grams; crude fibre, 1,533 grams—all the differences so far being in favor of the alfalfa. In the case of the mineral matter, the sheep fed on the saltbush digested 1,536 grams more than those receiving alfalfa. The daily differences in the amounts digested per sheep for the various fodder constituents were as follows: Crude proteids 12.66 grams, nitrogen-free extract 17.5 grams, both in favor of the alfalfa-fed sheep, which were gaining six-tenths of a pound daily, while the saltbush-fed sheep were losing almost exactly the same amount. The only food element digested in considerable excess by the alfalfa-fed sheep, 102 grams daily per sheep, was the crude fibre. This may be the cause of the great difference in the results.

§122. It is not evident what part the mineral matter may have played, though the amount actually absorbed by the sheep was large, 2,315 grams for the three sheep in five days, it produced no looseness of the bowels or other inconveniences that we could observe. This fodder did provoke a marked thirst, but the sheep did not suffer on this account. It does not seem probable that the loss of flesh was due to the mineral constituents contained in the plant. If we may reason from analogy in this case, we would be justified in comparing its results with those produced by sugar beet tops, which contain from 22 to 30 per cent. of ash when dried. The compounds absorbed in the case of the saltbush appear to be the sulfuric acid, chlorin and the alkalies. In eating a like amount of dried sugar beet tops the animals would consume larger amounts of these compounds than in the case of the saltbush, but it is a matter of common experience and knowledge that sheep thrive on the beet tops. If analogy holds in the case, we are justified in adopting the proposition that the loss is probably not due to the inorganic matter digested.

§123. Returning to our comparison of the energy relations of the alfalfa and the corn fodder, it is to be remembered that both fodders proved to be good ones. The alfalfa, however, producing a much greater gain in live weight than the corn fodder did under

the conditions of the experiment. The corn fodder, however, considering the coarseness of a large portion of it, one-third of it being stalks which the sheep ate very reluctantly, produced excellent results. I endeavored to induce the sheep to eat as much of the corn fodder as possible, so their ration was not made large enough to encourage them in selecting the most acceptable portions of the fodder. I do not know how much virtue there may be in the corn stalks, but they are certainly in no manner comparable to the stems of alfalfa, whose composition indicates that, without any leaves, they constitute a better fodder than some hays which are held in fair esteem, but sheep will not eat even these when coarse and hard.

§124. The amount of energy appropriated by the animal and the effect produced per unit of heat are the important points, especially from the standpoint of the feeder. Each gram of water free alfalfa is equivalent to 4,363 calories, 62.43 per cent. of which is available, and each gram of corn fodder is equivalent to 4,244 calories, 56 per cent. of which is available, *i. e.*, is taken up by the animal. The sheep receiving alfalfa appropriated 30,955,663 calories and those receiving corn fodder appropriated 19,424,180 calories, a difference of 11,531,483 calories. The former gained nine pounds in weight, the latter three and a half pounds, a difference of five and one-half pounds, which would indicate the consumption of 2,096,634 calories in the form of alfalfa for the production of one pound of gain in the live weight, which corresponds to very nearly two pounds of alfalfa, taking 453 grams as a pound and 62 as the percentage of heat appropriated by the sheep. The energy actually necessary to maintain the animals is considered to be the same in both cases; this is an assumption which is probably not wholly justified, neither is it shown that like amounts of energy in the corn fodder and alfalfa will produce the same results in pounds of mutton as is here tacitly assumed. The calorific value of the urine was not determined in either case, neither was the nitrogen in it determined.

§125. As already stated, the total dry matter consumed by the alfalfa fed sheep was 11,365 grams, while those receiving corn fodder consumed but 8,289. The dry matter digested was 7,046 and 4,642 grams, respectively. The coefficients of digestion found for this dry matter were 62.08 and 56.66, respectively. The percentages of the heat appropriated were very nearly the same as these coefficients, viz: 62.43 and 56.00 per cent. One would scarcely anticipate so close an agreement.

§126. The distribution of the heat values in the different extracts and the coefficients of these extracts, together with their respective amounts, show great differences between the fodders.

TABLE LXV.

	Alfalfa Extract Per cent.	Coefficient	Cornfodder Extract Per cent.	Coefficient
80% alcohol	27.50	73.88	29.61	73.79
Cold water	8.66	78.89	4.59	54.16
Hot water and malt	4.37	70.24	3.24	54.37
1% hydric chlorid	12.23	60.20	19.90	69.42
1% sodic hydrate	16.19	67.72	13.79	36.27
Chlorin	8.76	25.39	3.55	——
Residue	22.29	52.67	25.32	54.00

§127. The most patent difference here is in the case of the sodic hydrate, both in the quantity that is soluble and in the coefficient of digestion. The difference of about 2 per cent. in favor of the portion dissolved out of the alfalfa by the caustic soda is much less than the relative amounts of proteids present in the fodders; while the difference in the amount soluble is only 2 per cent., the coefficient of digestibility is more than double that of the portion dissolved out of the corn fodder.

TABLE LXVI.

THE CALORIFIC VALUE OF THE FODDERS AND THEIR RESPECTIVE EXTRACTS.

	Alfalfa	Corn Fodder
Original fodder	4363	4244
Extracts:		
Alcoholic (hot 80% alcohol)	4706	4224
Cold and hot water	3140	3009
One per cent. hydric chlorid	3596	4290
One per cent. sodic hydrate	5063	5003
Chlorin, etc.	5598	4663
Residue, cellulose	4210	4134

TABLE LXVII.

CALORIFIC VALUES OF THE FECES AND THEIR EXTRACTS.

	Alfalfa	Corn Fodder
Original	4525	4248
Extracts:		
Alcohol (hot 80% alcohol)	5739	5057
Cold and hot water	4123	2738
One per cent. hydric chlorid	4061	5069
One per cent. sodic hydrate	2997	4507
Chlorin	5842	4304
Residue, cellulose	4294	3714

TABLE LXVIII.

THE COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA AND CORN FODDER.

ALFALFA.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extracts*	5,074,240	1,599,724	3,474,516	68.51
1% hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
1% sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,045,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

CORN FODDER

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
1% hydric chlorid extract	7,691,970	2,774,812	4,914,158	63.88
1% sodic hydrate extract	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract	1,482,734	1,859,328	(— 376,594)	——
Residue or cellulose	9,264,294	3,829,138	5,435,160	58.67

§128. Though the preceding table is based upon the calorific values of the extracts calculated from the values of the residues, the total differs, in the case of the alfalfa, from that obtained by using the values obtained for the hay and feces by about 5 per cent., which is a closer agreement than I had anticipated. In the case of the corn fodder, the agreement is not so good, but is, even in this case, only 9.3 per cent; the calculated values being the higher in both cases.

§129. These results show that the fodders agree in this, that the alcoholic extract and the cellulose furnish a large percentage of the total heat value appropriated by the sheep, 16,691,297 calories out of a total of 31,720,459 calories, or 51 per cent., approximately. The heat yielded by the cellulose in the two fodders is nearly the same. The hydric chlorid and sodic hydrate extracts are reversed in the two fodders; that is, the sodic hydrate extract shows a very much higher value in the alfalfa and a very much lower one in the corn fodder than the hydric chlorid extract, yielding almost three times as much heat in the case of alfalfa and less than half as much in that of the corn fodder. The high proteid content of the alfalfa may correspond to the higher heat value of the sodic hydrate extract, but the distribution of the nitrogen among the extracts does not lend much probability to this idea, for the sodic hydrate solu-

*Aqueous extract includes all that was dissolved out by successive treatment with cold water, boiling with water for one hour and subsequent digestion with malt extract.

tion dissolves only about one-half of the nitrogen contained in the alfalfa, the other half being contained in the alcoholic extract (7-19) and in the hydric chlorid extract (1-10). The relative amounts of heat appropriated by the animals from these two extracts is remarkably different, 80.9 per cent. of that from the alfalfa being appropriated, while only 35.17 per cent. of that from the corn stalks. In the alfalfa the three portions, *i. e.*, extracts obtained by treatment with alcohol, and sodic hydrate and the residue, or that portion which we have called cellulose, yield five-sixths of the available heat; in the corn fodder it is the extracts removed by alcohol, hydric chlorid and the residue or cellulose that furnish almost six-sevenths of the total heat.

§130. These two fodders agree in showing that the alcoholic extract and the cellulose are two important factors in a fodder; they differ in regard to the third factor, one indicating that the portion soluble in sodic hydrate and the other that that soluble in hydric chlorid, is the third in importance. This is probably the big difference between the two, though both are capable of furnishing more energy than is necessary to simply maintain the animal and contain no constituent whose physiological action is detrimental.

§131. There are many hints that the results are modified to a considerable extent by the fecal matter proper, but it is not separable from the undigested residue of the fodder.

§132. The difference between the sodic hydrate extracts in these two cases is great, not only in the quantity of heat represented, but also in the availability of the heat value of the substances taken into solution. The sheep consumed, in round numbers, ten millions heat units with the alfalfa which had proven insoluble in the alcohol, water and hydric chlorid, of which 80.92 per cent. were available, while the others consumed but six millions from the corn fodder, of which only 35.17 per cent. were available, making an actual difference of over six millions of heat units obtained from this portion of these fodders. These quantities are those actually consumed and appropriated by the sheep and not comparisons based on like weights of the fodders. Such a comparison would result in a more favorable showing for the corn fodder.

§133. The distribution of the nitrogenous substances in the various extracts of alfalfa hay have been given in a previous table and also that for the corn fodder. The big feature in the case of the alfalfa is that nearly 50 per cent. of the total digestible nitrogenous substances is insoluble in alcohol water and hydric chlorid but soluble in sodic hydrate and, further, that 80.89 per cent. of the total, soluble in sodic hydrate, is digestible. This ratio holds, too, for native hay, but the coefficient of digestion for the nitrogenous mat-

ters soluble under these conditions is but 58.63 per cent. In the corn fodder we have an entirely different distribution of the proteids among the various extracts, over two thirds of the total digestible nitrogenous substances being soluble in boiling eighty per cent. alcohol and nearly one-half of the nitrogen consumed is soluble in the same menstruum. The large amount of nitrogen, calculated as proteids, in the feces, soluble in sodic hydrate, points clearly, as I interpret it, to the presence of nitrogenous fecal matter, even in excess of the total amount, soluble in this reagent, present in the fodder consumed. This is the most marked instance, so far met with, indicative of the disturbing influence of fecal matter upon the results of our work, but it is not the only one. It seems to be almost a rule that the nitrogen removable by treatment with chlorin, sodic hydrate and sulfurous acid is greater in the feces than in the fodder consumed, though in this particular case it is less. The amount of nitrogen involved in this portion, nitrogen removable by treatment with chlorin, etc., as well as that contained in the final residue, designated cellulose, and also in the portion removed by successive treatment with cold water, hot water and malt, is quite small and, for this reason, of little importance. Their frequent excess in the feces points to the influence of the presence of fecal matter, which differs in the case of different fodders.

§134. The results of the study of the distribution of the nitrogen in the respective extracts, as well as the distribution of the heat values of the extracts, indicate that the greatest differences between these two fodders is in the character of the two extracts obtained by hydric chlorid and sodic hydrate. In studying the results, it is to be borne in mind that there are actually a larger edible ration fed in the case of the alfalfa than in that of the corn fodder, because, as before stated, I tried to induce the sheep to consume the largest possible portion of the corn fodder fed. I am quite convinced that I would have obtained results more favorable to the corn fodder had I fed them from one-third to one-half more of it and thus made it possible for the sheep to select the portions which they liked to a greater extent than they did. There was eaten 11,365 grams of dry matter as alfalfa, and but 8,289 grams as corn fodder. In order to have induced the sheep to eat the same amount of corn fodder as they actually did eat of alfalfa, it would probably have been necessary to increase the ration by one-half. I have so far purposely avoided comparing these fodders weight for weight. It may be well to do so, but very briefly. The three sheep appropriated 19,424,180 calories from the 8,289 grams of corn fodder consumed, or 2,344 calories per gram, while a like number of sheep appropriated 30,955,663 calories from 11,365 grams of alfalfa, or 2,736 calories per

gram, which shows a difference in favor of the alfalfa of only 392 calories per gram of fodder eaten.

SORGHUM FODDER.

§135. This fodder was grown in the extreme eastern part of the State without irrigation. It was cut when a few canes were far enough advanced to mature the seed in shock. The fodder stood in shock till the latter part of the winter, but was not fed till the latter part of the spring. The variety was Minnesota Early Amber.

The following is the analytical data:

TABLE LXIX.

FODDER ANALYSIS.

SORGHUM FODDER.		CORRESPONDING FECES. Sheep No. 1.	
Moisture	5.75	Moisture	6.80
Ash	8.17	Ash	11.46
Ether extract	1.55	Ether extract	1.28
Proteids	5.80	Proteids	8.48
Crude fibre	23.26	Crude fibre	28.16
Nitrogen-free extract	55.47	Nitrogen-free extract	43.82
	100.00		100.00

TABLE LXX.

ASH ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Percentage of ash in fodder	8.77	Percentage of ash in feces	11.46
Carbon	0.000	Carbon	0.000
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.120
Ignition	(1.260)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen-Chlorin	1.546	Oxygen-Chlorin	0.355
	100.000		100.000

TABLE LXXI.

ULTIMATE ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Carbon	42.402	Carbon	43.926
Hydrogen	5.748	Hydrogen	5.826
Nitrogen	0.928	Nitrogen	1.362
Sulfur	0.085	Sulfur	0.115
Chlorin	0.553	Chlorin	0.305
Ash and oxygen	50.284	Ash and oxygen	48.466
	100.000		100.000

§136. The average coefficients of digestion found for this fodder were as follows: Dry matter, 58.46; ash, 44.61; fat, 64.87; proteids, 43.06; crude fibre, 49.23; nitrogen-free extract, 61.06. The three animals to which this fodder was fed lost eight and one-half pounds in five days and consumed 30 to 31 pounds of dry matter per thousand weight of animal. The fodder was evidently acceptable to the animals, but the results were unfavorable.

TABLE LXXII.

PROXIMATE ANALYSIS.

SORGHUM FODDER.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	35.492	35.727	35.60
Cold water, 24 hours, extracted	3.966	4.065	4.02
Hot water extracted	7.634	7.468	7.55
Hydric chlorid 1% sol. extracted	18.955	17.480	18.22
Sodic hydrate 1% sol. extracted	11.048	11.982	11.52
Chlorin, etc., extracted	4.327	4.579	4.45
Cellulose	18.578	18.699	18.64
SUGARS IN THE EXTRACTS.			
Glucose in alcoholic extract	9.31	9.46	9.39
Sucrose in alcoholic extract	6.80	7.22	7.01
Gums in cold water extract	0.36	0.32	0.34
Starch in hot water extract	2.45	2.52	2.49
Xylan in hydric chlorid extract	13.59	13.78	13.68
Xylan in sodic hydrate extract	0.66	0.68	0.67

TABLE LXXIII.

PROXIMATE ANALYSIS.

SORGHUM ORTS.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	41.809	42.624	42.21
Cold water in 24 hrs. extracted	2.960	3.040	3.00
Hot water extracted	2.581	2.400	2.49
Hydric chlorid 1% sol. extracted	17.499	17.412	17.46
Sodic hydrate 1% sol. extracted	12.474	12.727	12.60
Chlorin, etc., extracted	3.066	3.114	3.09
Cellulose	19.611	18.683	19.15

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.........	Lost	14.95	14.95
Sucrose in alcoholic extract.........	Lost	10.73	10.73
Gums in cold water extract.........	0.59	0.46	0.53
Starch in hot water extract.........	1.18	1.05	1.12
Xylan in hydric chlorid extract.....	14.94	15.51	15.23
Xylan in sodic hydrate extract......	0.80	0.82	.81

TABLE LXXIV.

FECES OF SHEEP FED ON SORGHUM.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	15.180	14.986	15.08
Cold water in 24 hrs. extracted......	3.728	3.669	3.70
Hot water extracted	4.190	5.005	4.60
Hydric chlorid 1% sol. extracted.....	22.481	22.205	22.34
Sodic hydrate 1% sol. extracted.....	20.461	20.270	20.37
Chlorin, etc., extracted	11.172	10.039	10.61
Cellulose	22.788	23.826	23.30
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.........	None	None	None
Sucrose in alcoholic extract.........	None	None	None
Gums in cold water extract.........	0.20	0.20	0.20
Starch in hot water extract.........	0.36	0.39	0.38
Xylan in hydric chlorid extract.....	13.45	13.14	13.30
Xylan in sodic hydrate extract......	1.11	1.11	1.11

TABLE LXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract..	4742.9	738.1	4004.8	731.3	3273.5	81.74
Total cold water extract.	535.6	52.5	483.1	179.4	303.7	62.86
Total hot water extract.	1005.9	43.6	962.3	223.1	739.2	76.82
Total hydric chlorid ext.	2427.5	305.3	2122.2	1083.3	1038.9	48.95
Total sodic hydrate ext..	1534.8	220.3	1314.5	987.8	326.7	24.85
Total chlorin, etc., ext...	592.9	54.0	538.9	514.5	24.4	4.53
Residue, cellulose	2483.4	334.9	2148.5	1129.9	1018.6	47.41
	13323.0	1748.7	11574.3	4849.3	6725.0	58.10

§137. The coefficients for the dry matter obtained with the three sheep were as follows: 57.53, 58.22 and 59.63; average 58.46 per cent.

TABLE LXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES CONTAINED IN SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcoholic ext...	1251.0	261.4	989.6	0.0	989.6	100.00
Sucrose in alcohol extract.	934.0	187.6	746.4	0.0	746.4	100.00
Gums in cold water ext...	45.3	9.3	36.0	9.7	26.3	73.06
Starch in hot water ext...	331.7	19.6	312.1	18.4	293.7	94.11
Xylan in hydric chlorid ext	1822.6	266.3	1556.3	645.0	911.3	58.56
Xylan in sodic hydrate ext	89.3	14.2	75.1	53.8	21.3	28.26
	4473.9	758.4	3715.5	726.9	2988.6	80.43

TABLE LXXVII.

FURFUROL FOUND IN SORGHUM FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Sorghum Per cent.	Orts Per cent.	Feces Per cent.
Original	9.680	10.069	12.530
Residue after treatment with 80% alcohol...	9.410	9.856	12.016
Residue after treatment with cold water....	Same	Same	Same
Residue after treatment with hot water and malt	8.638	Same	11.628
Residue after treatment with hydric chlorid	3.322	4.626	4.662
Residue after treatment with sodic hydrate.	1.957	2.387	2.456
Residue after treatment with chlorin, etc....	1.746	1.641	Not det

TABLE LXXVIII.

COEFFICIENTS OF DIGESTION FOR FURFUROL IN SORGHUM AND IN THE PORTIONS DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Sorghum	1290.5	176.1	1114.4	6076.	506.8	45.48
Soluble in 80% alcohol ...	36.0	3.7	32.3	24.9	7.4	22.91
Soluble in cold and hot water	10.3	5.4	4.9	18.8	(—13.9)	.....
Soluble in 1% hydric chlorid	708.3	86.0	622.3	337.8	284.5	45.72
Sol. in 1% sodic hydrate...	182.7	39.2	143.5	107.0	36.5	25.44
Soluble in chlorin, etc....	27.3	13.0	14.3	111.9	106.3	48.72
Remaining in the cellulose	232.6	28.7	203.9			
			1120.9	600.4	520.9	46.46

METHOXYL GROUP.

§138. The amount of this group found in the fodder was 1.027 per cent.; in the feces, 3.379 per cent. No determination of this group was made with the orts. The result shows an excess of 45 grams in the feces, which is due either to some mistake in the

determination or indicates the probable presence of this group in fecal matter. The results of our determinations, 14 in all, indicate a much higher percentage of this group in the feces than in the fodder consumed. The results in this case are very high for the feces, but it was done in triplicate and the three determinations agree very well.

AMID NITROGEN.

§139. The amount of amid nitrogen found in the sorghum was small, corresponding to only 0.884 per cent. calculated as proteids. We found none or only a trace in the orts and 1.168 per cent. in the feces. The coefficient of digestion found in this case was 51.91 per cent. This is somewhat higher than the coefficient found for the total nitrogen calculated as proteids, 8.95 per cent. higher.

HEAT APPROPRIATED BY THE ANIMALS.

§140. The air-dried fodder possessed a heat value of 3,890 calories per gram; the orts, 1,749 grams in weight, are supposed to have the same value; the feces, which weighed 4,849 grams, had a fuel value of 4,111 calories per gram. The sheep consumed 11,574 grams of air-dried fodder and appropriated 55.72 per cent. of its fuel value.

§141. We did not determine the distribution of the proteids in the various extracts of sorghum and their respective coefficients of digestion, neither did we make a detailed study of the fuel values of the respective extracts, etc.

§142. This fodder had already proved to be a disappointment, but not to as great an extent as the saltbush, so I scarcely hoped to gain anything by extending this work.

§143. The sheep fed on this fodder lost in the five days between the two weighings, 3, 2½ and 3 pounds, respectively, an aggregate loss of 8½ pounds. They appropriated in this period 25,088,621 calories, which was evidently not sufficient to maintain the animals in good condition. The coefficients of digestion for this fodder were quite as promising as those obtained for corn fodder, with the exception of that obtained for the crude fibre; the latter coefficient is nearly 8 per cent lower in the sorghum than in the cornfodder. The dry matter consumed by the sheep when fed corn fodder was 8,289 and 10,934 when fed sorghum; the same sheep were used in these two experiments and the conditions were equally favorable in both series. The sheep all gained on the corn fodder and lost while being fed the sorghum fodder. The sheep appropriated 19,424,180 calories while feeding on corn fodder, as against 25,088,621 while feeding on sorghum. The urine was unfortunately not collected

and analyzed. The water drank while feeding on corn fodder weighed 27½ pounds, and as the weather was cold, the water was warmed to about 22° C. before it was offered to the sheep. The weight of water consumed while feeding on sorghum was 60½ pounds and was not warmed, as the temperature of the water was at this time about 15° C. The daily consumption of water was a trifle over twice as much per sheep while feeding or sorghum as while feeding on corn fodder. In the former case, it was four pounds, and in the latter nearly two pounds per sheep. This amount of water, 4 pounds, is probably not excessive, as the sheep fed on alfalfa drank almost 4¾ pounds daily and made a gain of about three pounds each in the five days, but they did appropriate nearly 6,000,000 more calories than the sheep feeding on sorghum. The three sheep used in the experiment with the alfalfa were not the same three used in the sorghum experiment, but each of the sheep used in the alfalfa experiment gained about three pounds in five days, and each of those used in the sorghum lost about three pounds in five days.

§144. It is evident from the context that the gain and loss is in terms of live weight, this being the only kind of gain or loss considered in this bulletin.

SALTBUSH, *Atriplex argentea.*

§145. This plant is used to some extent in the eastern part of this state in making a hay to feed during heavy storms when the stock cannot otherwise obtain forage enough to sustain themselves. I undertook the study of this plant in the hope that it might prove worthy of commendation as a fodder, as some of the Australian saltbushes have proved to be. The uncertainty of raising crops in the eastern portions of the state make it desirable to find some plant which will serve the purpose of a good forage and which will grow sufficiently well under the prevailing conditions to produce a fair crop. The people most directly concerned in this have used this native plant; therefore, I undertook its examination.

§146. Its effects upon the sheep, three in number, were not injurious. They seemed to suffer no inconvenience except that they drank a large quantity of water and voided an excessive amount of urine, which had an offensive odor. They otherwise appeared healthy. They ate freely of this hay and chewed their cuds contentedly. If I had made a second experiment and not allowed them to drink so much water, more favorable results might have been obtained.

TABLE LXXIX.

ANALYTICAL DATA FOR THE SALTBUSH, *Atriplex argentea.*

FODDER ANALYSIS.

SALTBUSH.		CORRESPONDING FECES. Sheep No. 4.	
Moisture	5.32	Moisture	6.53
Ash	19.28	Ash	10.53
Ether extract	1.46	Ether extract	1.32
Proteids	9.73	Proteids	6.27
Crude fibre	27.33	Crude fibre	40.44
Nitrogen-free extract	36.88	Nitrogen-free extract	34.91
	100.00		100.00

TABLE LXXX.

ANALYSIS OF THE ASHES.

SALTBUSH.		CORRESPONDING FECES.	
Carbon		Carbon	
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.140
Ignition	(1.26)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen equivalent to chlorin	1.546	Oxygen equivalent to chlorin	.355
	100.000		100.000

ANALYSIS OF THE ASH.

TABLE LXXXI.

ULTIMATE ANALYSIS.

SALTBUSH. Atriplex argentea.		CORRESPONDING FECES.	
Carbon	41.370	Carbon	44.700
Hydrogen	5.581	Hydrogen	5.961
Nitrogen	1.557	Nitrogen	1.003
Sulfur	0.320	Sulfur	0.205
Chlorin	3.965	Chlorin	0.234
Ash	19.280	Ash	10.530
Oxygen (approx.)	27.927	Oxygen (approx.)	37.367
	100.000		100.000

§147. The sulfur and chlorin determinations were made on samples of the fodder, as in previous instances, and not calculated from the ash.

TABLE LXXXII.

SALTBUSH, *Atriplex argentea*.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	22.243	21.877	22.06
Cold water in 24 hrs. extracted......	6.777	7.101	6.94
Hot water extracted	5.762	5.852	5.81
Hydric chlorid 1% sol. extracted.....	19.214	19.719	19.46
Sodic hydrate 1% sol. extracted.....	15.734	17.686	16.71
Chlorin, etc., extracted	10.803	9.762	10.28
Cellulose	19.467	18.003	18.74
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.........	0.88	0.63	0.76
Sucrose in alcoholic extract.........	1.28	1.23	1.25
Gums in cold water extract.........	0.57	0.57	0.57
Starch in hot water extract.........	1.45	1.45	1.45
Xylan in hydric chlorid extract.....	7.48	7.62	7.55
Xylan in sodic hydrate extract......	2.11	1.67	1.89

TABLE LXXXIII.

SALTBUSH ORTS.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	21.537	21.391	21.47
Cold water in 24 hrs. extracted......	6.548	6.317	6.43
Hot water extracted	3.239	3.685	3.46
Hydric chlorid 1% sol. extracted.....	17.301	17.450	17.38
Sodic hydrate 1% sol. extracted.....	17.152	17.289	17.22
Chlorin, etc., extracted	11.856	11.857	11.86
Cellulose	22.367	22.011	22.18
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.........	0.61	0.50	0.56
Sucrose in alcoholic extract.........	1.10	1.13	1.12
Gums in cold water extract.........	0.92	0.70	0.81
Starch in hot water extract.........	1.25	1.18	1.22
Xylan in hydric chlorid extract.....	7.29	7.40	7.35
Xylan in sodic hydrate extract......	2.37	2.46	2.42

TABLE LXXXIV.

FECES OF SHEEP FED ON SALTBUSH.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	12.802	11.295	12.05
Cold water in 24 hrs. extracted......	3.248	3.719	3.48
Hot water extracted	3.050	3.023	3.04
Hydric chlorid 1% sol. extracted.....	21.700	22.315	22.00
Sodic hydrate 1% sol. extracted.....	16.902	20.464	18.68
Chlorin, etc., extracted	18.932	15.319	17.13
Cellulose	23.366	23.865	23.62
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.........	None	None	None
Sucrose in alcoholic extract.........	0.21	0.21	0.21
Gums in cold water extract.........	0.38	0.38	0.38
Starch in hot water extract.........	None	None	None
Xylan in hydric chlorid extract.....	5.03	6.55	5.79
Xylan in sodic hydrate extract......	4.15	3.47	3.81

TABLE LXXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SALTBUSH, *Atriplex Argentea.*

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract...	4250.1	682.6	3567.5	1052.8	2514.7	70.49
Total cold water extract..	1337.1	204.4	1132.7	304.1	828.6	73.15
Total hot water and malt extract	1119.4	109.0	1010.4	265.6	744.8	73.54
Total hydric chlorid ext..	3749.2	552.7	3196.5	1922.1	1274.4	39.87
Total sodic hydrate extract	3219.3	547.3	2672.0	1632.0	1040.0	49.00
Total chlorin, etc., extract	1980.6	376.9	1603.7	1496.6	107.1	6.28
Total residue, cellulose ...	3610.5	705.2	2905.3	2063.6	841.7	28.97
	19266.2	3178.1	16088.1	8736.8	7351.3	45.70

The general coefficients obtained for the digestibility of the dry matter were 46.40, 45.84 and 46.50, with the individual sheep; average, 46.25 per cent.

TABLE LXXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN THE SALTBUSH, *Atriplex Argentea.*

(As indicated by the sugars obtained from the various extracts.)

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract	146.4	17.8	128.6	0.0	128.6	100.00
Sucrose in alcohol extract	240.3	35.6	204.7	14.6	190.1	92.87
Gums in cold water ext...	109.8	25.7	84.1	32.2	51.9	61.71
Starch in hot water and malt extract	279.4	38.8	240.6	0.0	240.6	100.00
Xylan in hydric chlorid ext	1454.6	233.6	1221.0	505.9	715.1	58.57
Xylan(?) in sodic hydrate extract	364.1	76.9	287.2	332.9	(—45.7)	———

TABLE LXXXVII.

FURFUROL FOUND IN SALTBUSH, *Atriplex argentea*, AND IN THE CORRESPONDING ORTS AND FECES.

	Saltbush Per cent.	Orts Per cent.	Feces Per cent.
Original	9.642	10.488	10.926
Residue after treatment with 80% alcohol...	9.642	10.363	10.926
Residue after treatment with cold water....	9.058	Same	Same
Residue after treatment with hot water and malt	7.608	10.140	10.440
Residue after treatment with hydric chlorid.	4.708	6.036	5.298
Residue after treatment with sodic hydrate..	2.570	2.985	3.364
Residue after treatment with chlorin, etc....	2.042	1.216	Not det

TABLE LXXXVIII.

COEFFICIENTS OF DIGESTION FOUND FOR FURFUROL IN THE SALTBUSH, *Atriplex argentea*.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Furfurol in Saltbush.....	1857.6	333.2	1524.4	954.6	569.8	37.38
Furfurol soluble in 80% alcohol	0.0	0.0	0.0	0.0	0.0	———
Furfurol soluble in water and malt	391.9	9.6	382.3	42.1	340.2	88.99
Furfurol soluble in 1% hydric chlorid	558.7	130.4	428.3	449.6	(—21.3)	———
Furfurol soluble in 1% sodic hydrate ...	412.0	97.0	315.0	169.0	146.0	46.35
Furfurol soluble in chlorin, etc.	101.7	56.2	45.5	293.9	106.4	26.49
Furfurol remaining in the residue	393.4	38.6	354.8			
			1525.9	954.6	571.3	37.37

TABLE LXXXIX.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF THE SALTBUSH, *Atriplex argentea*.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	691.7	62.3	629.4	76.1	553.3	87.91
Cold water	57.0	26.7	30.3	45.4	(—15.1)	———
Hot water and malt	108.4	6.7	101.7	37.1	64.6	63.52
1% hydric chlorid	133.1	27.8	105.3	59.4	45.8	43.50
1% sodic hydrate, ...	618.4	79.5	538.9	161.3	377.6	70.10
Chlorin, sodic hydrate and sulfurous acid	236.4	18.4	218.0	154.5	63.5	29.13
Remaining in cellulose...	—29.3	6.8	22.5	22.4	00.1	0.00
	1874.3	228.2	1646.1	556.3	1098.8	66.21

§148. The coefficients of digestion found for the proteids with the three sheep were 67.56, 64.69 and 66.83. The average is 66.36. Bulletin 93, page 38.

METHOXYL GROUP IN THE SALTBUSH, *Atriplex argentea.*

§149. The saltbush hay was examined for the presence of this substance in the same manner that the other fodders were examined. The amount found was 2.104 per cent. I assume that the difference in the amount of this group present in the orts and in the hay is so small that no serious error is made in considering them the same, and I, therefore, made no attempt to determine this group in the orts. The amount in the feces is 2.929 per cent. The total weight of this group consumed was 338.49 grams; the amount voided was 255.90 grams; the amount digested was 82.6 grams, or 24.40 per cent.

§150. Alfalfa, timothy, native hay, corn fodder and the saltbush agree in showing that the substances containing this group are broken down to the extent of about 25 per cent. of the amount present. The result obtained with sorghum was wholly unsatisfactory; though the determination of this group in the feces, corresponding to the sorghum, was made three times and in the sorghum itself twice, with satisfactory agreement in every case. The result, however, indicates that fecal matter may yield this group or, perhaps, it is safer to interpret it that the substances containing this group in the case of sorghum are not digested at all, and that the excess of methoxyl in the feces is due to some error in our determination which we failed to detect, even though we repeated it.

AMID NITROGEN.

§151. The amid nitrogen found in the saltbush hay corresponded to 4.180 per cent of proteids, while that in the orts represented only 1.556 per cent. of proteids. We failed to find any in the feces. As we usually interpret these results, the amid nitrogen was wholly digestible, or has a coefficient of 100.00 per cent.

THE FUEL VALUE OF SALTBUSH, *Atriplex argentea.*

§152. The total dry matter consumed by the sheep in five days was 15,253 grams. We found the calorific value of this dry matter to be 3,886 calories per gram, or a total of 59,273,158 calories. The dry matter in the feces was 8,200 grams, with a heat value of 4,398 calories per gram, or a total of 36,063,600 calories. The sheep, accordingly, appropriated 23,224,811 calories, or 39.16 per cent. of the fuel value—the lowest coefficient of all the fodders used.

§153. The amount of urine voided in this instance was so ex-

ceptionally large that it certainly ought to have been collected, weighed and examined, at least the nitrogen determined. The animals' systems were certainly flooded by the large amount of water drank, 196 pounds in five days, which is a little more than three times as much as the same sheep drank when fed on alfalfa hay and over four times as much as when fed on timothy hay. The heat required to raise this quantity of water from the temperature at which it was drank, 14.5° C., to the body temperature, taken as 101° F., would be 2,014,387 calories. So large a factor as this must have considerable influence upon the effects produced by the fodder, aside from the lively diffusion induced by the presence of an unusual quantity of water in the system.

TABLE XC.

The dry saltbush hay had the following approximate composition:

Solvent.	Per cent.
Boiling 80% alcohol	17.681
Cold water, 24 hours digestion	7.329
Hot water and malt extract	6.133
One per cent. hydric chlorid	20.560
One per cent. sodic hydrate	17.649
Chlorin, sodic hydrate and sulfurous acid	10.860
Residue, cellulose	19.788
	100.000

TABLE XCI.

THE FUEL VALUES OF THE SALTBUSH HAY AND THE RESPECTIVE RESIDUES.

Dry Saltbush, Atriplex argentea hay	3886 calories
The residue after extraction with 80% alcohol	3986 calories
The residue after extraction with cold water	4284 calories
The residue after extraction with hot water and malt	4346 calories
The residue after extraction with 1% hydric chlorid	4854 calories
The residue after extraction with 1% sodic hydrate	4712 calories
The residue after extraction with chlorin, etc.	4458 calories

TABLE XCII.

THE HEAT UNITS REMOVED FROM ONE GRAM OF SALTBUSH HAY BY THE VARIOUS SOLVENTS.

Boiling 80% alcohol	565 calories
Cold water, 24 hours digestion	108 calories
Hot water and malt extract	220 calories
One per cent. hydric chlorid	649 calories
One per cent. sodic hydrate	900 calories
Chlorin, sodic hydrate and sulfurous acid	558 calories
The residue, or cellulose	886 calories
	3886 calories

TABLE XCIII.

THE FUEL VALUES OF THE RESPECTIVE EXTRACTS OF THE SALT-BUSH, *Atriplex argentea.*

One gram of the alcoholic extract	3196 calories
One gram of the cold water extract	1474 calories
One gram of the hot water and malt extract	3587 calories
One gram of the hydric chlorid extract	3157 calories
One gram of the sodic hydrate extract	5099 calories
One gram of the chlorin, etc., extract	5138 calories
One gram of the residue, cellulose	4458 calories

TABLE XCIV.

THE DRY FECES GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

Solvent.	Per cent. Dissolved.
Boiling 80% alcohol	6.278
Cold water, 24 hours digestion	3.711
Hot water and malt extract	3.235
One per cent. hydric chlorid	23.452
One per cent. sodic hydrate	19.909
Chlorin, sodic hydrate and sulfurous acid	18.249
Residue, cellulose	25.166
	100.000

TABLE XCV.

THE FUEL VALUES OF THE DRY FECES (*Atriplex argentea*) AND THE RESPECTIVE RESIDUES PER GRAM.

The dry feces	4398 calories
The residue after extraction with 80% alcohol	4323 calories
The residue after extraction with cold water	4334 calories
The residue after extraction with hot water and malt	4379 calories
The residue after extraction with 1% hydric chlorid	4871 calories
The residue after extraction with 1% sodic hydrate	4801 calories
The residue after extraction with chlorin, etc., cellulose	4398 calories

TABLE XCVI.

THE HEAT UNITS REMOVED FROM ONE GRAM OF FECES BY SUCCESSIVE TREATMENT WITH THE RESPECTIVE SOLVENTS.

Boiling 80% alcohol	346 calories
Cold water, 24 hours digestion	151 calories
Hot water and malt extract	101 calories
One per cent. hydric chlorid	715 calories
One per cent. sodic hydrate	1002 calories
Chlorin, sodic hydrate and sulfurous acid	976 calories
Remaining in the residue or cellulose	1107 calories

TABLE XCVII.

THE FUEL VALUE OF THE RESPECTIVE EXTRACTS OF THE FECES PER GRAM.

Alcoholic extract	5510 calories
Cold water extract	4069 calories
Hot water extract	3122 calories
One per cent. hydric chlorid extract	3049 calories
One per cent. sodic hydrate extract	5033 calories
Chlorin, sodic hydrate and sulfurous acid extract	5347 calories
The residue or cellulose	4398 calories

TABLE XCVIII.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF THE SALTBUSH (*Atriplex argentea*) HAY.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Eighty per cent. alcohol extract	8,619,612	2,837,650	5,781,962	67.07
Cold water extract	1,647,934	1,236,976	410,956	24.94
Hot water and malt extract....	3,357,432	827,330	2,530,102	75.37
1% hydric chlorid extract......	9,900,352	5,863,227	4,037,125	40.78
1% sodic hydrate extract......	13,721,409	8,218,889	5,502,520	40.09
Chlorin, sodic hydrate and sulfurous acid extract	8,508,528	7,999,112	509,416	5.99
The residue or cellulose	13,449,786	9,077,472	4,372,314	32.51
	59,205,051	36,060,656	23,149.533	39.12

§154. The coefficient obtained by using the composite samples of the hay and feces was 39.16 per cent., the same as we here obtain by calculation from the values obtained for the various extracts and the analysis of the fodder.

§155. The ordinary fodder analysis indicates no reason why this saltbush hay should not be, at least, a fairly good fodder. There is present more crude proteids than in the average hay, as much nitrogen-free extract as in alfalfa hay and less crude fibre than in alfalfa hay, timothy hay, native hay or corn fodder. The only abnormally abundant constituent is the ash, which amounts to nearly one-fifth of the weight of the dry hay, but three-tenths of this is sand. This amount though large is less than is found in the dried leaves of the sugar beet which are fed with excellent results, to both cattle and sheep. The percentage of ash in the dried beet leaves, not including the crown, ranges from 23 to 27 and to even more than 30 per cent. in the leaves of fodder beets. In this saltbush the ash was found to be 19.28 per cent., somewhat less than the amount found in our sugar beet leaves. The analysis of this ash shows less chlorin, sulfuric acid and soda than the ash of the beet leaves and no more soda than the alfalfa ash. The results of the feeding experiment were, however, not favorable, as each of the three sheep lost weight, one sheep lost one-half pound, one two pounds, and the third six pounds. This loss of six pounds may have been due to the individuality of the sheep more than to the fodder, but aside from this the results in the other two cases show that the fodder is a very poor one. The coefficients of digestion obtained for these groups of food elements, *i. e.*, the ash, proteids, crude fibre and nitrogen-free extract, show some extreme differerences, *i. e.*, the coefficient of digestion for the crude fibre as shown by the three sheep was 6.02, 15.35 and 3.49 respectively, and the sheep with which we obtained a coefficient of 15.35 per cent. was the

one that lost the most, six pounds in five days. The crude proteids, on the other hand, show the highest coefficients of digestion obtained except for the proteids contained in the alfalfa. The total proteids digested by the three sheep fed on alfalfa hay with a gain of nine pounds was 1325 grams, the proteids digested by the sheep fed on the saltbush hay with a total loss of eight and one-half pounds, was 1090 grams, a difference of 235 grams in the weight of the proteids digested. The coefficient obtained for the nitrogen-free extract was very low, 49.16, whereas it was practically 73 in the case of the alfalfa whose nitrogen-free extract has a very high coefficient of digestion. The percentage of the nitrogen-free extract present in the hay is about the same as in alfalfa hay; that for the crude fibre is somewhat lower than in the other fodders forming the subjects of this study, but the percentage of ash is decidedly higher than even the alfalfa and has a very high coefficient of digestion, 71.55, against 57.67 for the alfalfa ash. The high percentage of ash found for the saltbush hay is partly due to the presence of a great deal of sand amounting to 30 per cent. of the ash. The high coefficient of digestion for the ash is fully accounted for by the fact that the base occurring in the largest quantity is potash, making over 75 per cent. of the bases present. The potash is very largely absorbed by the system while lime and magnesia are absorbed by the system in small quantities and these make up the rest of the bases. It is to be noted that in this saltbush so good as no soda salts are present in its ash, only 0.073 per cent. sodic oxid. I have already made mention of the fact that this fodder caused the animals to drink very freely, as much as 15 pounds of water a day, which is very much more than they drank when fed on other fodders, ten times as much as the minimum that the same sheep drank when fed on timothy hay and twice as much as the maximum when fed on alfalfa hay.

§156. If we take up what I have designated as the proximate analysis of this saltbush, *i. e.,* the relative amounts dissolved out of the fodder by treating it successively with 80 per cent. alcohol, etc., we find that it is quite unlike the other fodders, but approaches most nearly to timothy hay, from which it differs in two respects, *i. e.,* in having somewhat less cellulose and in the amount of material removed by chlorin which is much larger than in the case of timothy or any of the other fodders.

§157. This timothy hay proved to be a poor fodder, each of the sheep losing flesh while receiving it as an exclusive ration. The results with the saltbush were very uneven, one sheep lost but one-half pound in the five days, another lost six pounds. I take it that the saltbush was really bad for the latter sheep, though it ate the hay freely and digested a little more dry matter than the sheep that

lost only one-half pound. The difference in the loss cannot be attributed to this sheep's having drunk more water than the other, for it drank less by a few pounds, so that the disturbing influence of an excessive amount of water would probably not be greater in the one case than in the other.

§158. The portion removed from the fodders by treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid, is usually small, but amounts to 10.28 per cent. in the saltbush. The coefficient of digestion found for this portion is always low. In this case it was found to be only 6.28 per cent. The low coefficient for this portion may be more apparent than real. The percentage of it present in the feces is always comparatively high, in some cases exceeding the amount consumed. This may be, and probably is due to fecal matter, a large percentage of which is removable by this chlorin treatment, which of course would lower the coefficient found, even to the extent of reducing it to zero or showing, as is the case of some extracts, that there was more voided than was ingested.

§159. The sucrose determination in several of the fodders is rendered very doubtful, almost certainly erroneous, by the fact, as the investigation shows conclusively, that some of the substances which yield furfurol are taken into solution by alcohol and presumably yield a reducing sugar when the extract is inverted by heating with dilute acid. This doubt does not attach to the glucose, as this determination does not involve the inversion of the solution, unless such may have taken place during the repeated boilings with alcohol or during its evaporation, which was done on the water bath to avoid either local or general overheating.

§160. The fact that the alcoholic extract of the feces, corresponding to the saltbush, shows the presence of some substance equivalent to 0.21 per cent. of sucrose cannot be taken as conclusively showing the presence of sucrose, but merely that the extract contains some material susceptible of yielding a reducing power equal to this. In the case of corn fodder and sorghum, especially as a saccharine variety was used, the presence of some sucrose in the alcoholic extract of the fodder was to be expected, but the feces corresponding to these fodders yield no sucrose to the boiling 80 per cent. alcohol. The same doubt attaches itself to the starch determination that has been mentioned in connection with the sucrose, *i. e.*, we have depended upon boiling the fodder with water for one hour, cooling it and adding malt extract to bring the starch into solution, but we observe that this process removes enough furfurol in every case in which any starch was found to raise a question as to whether the reducing power was due to inverted starch or to a pentosan.

§161. The sugar found in the hydric chlorid extract of the saltbush and in the other fodders is probably xylose, except in alfalfa in which case the mucic acid found is very nearly equal to the sugar obtained by the Fehling solution and only a small portion can be attributed to xylose. My results with corn fodder are not satisfactory, but the four tests made agree in showing the presence of some mucic acid. In this case we know that both glucose and sucrose were present and whether their presence may have given rise to a mistake or not may be a question. Assuming that they did not, it would appear that other hexoses as well as pentoses are present in this fodder. In this event, the three fodders, alfalfa hay, corn fodder, and saltbush hay, are quite unlike and we find the coefficients of digestion for the sugars formed by the thorough inversion of the hydric chlorid extract to be 83.96, 89.22 and 58.57 respectively, which would indicate that the source of this sugar is different in the saltbush form than in the other two fodders. As already stated it is probably due to galactan in the alfalfa and possibly to both hexose and pentose groups in the corn fodder. The digestibilty of the hydric chlorid extract, that is all that this reagent dissolves out of these fodders, is nearly the same in the alfalfa and corn fodder, 60 per cent. in the former, and 63.88 per cent. in the latter, but it is only 39.88 per cent. for that of the saltbush.

§162. The furfurol has been considered as such and no attempt has been made to specify the particular source from which it was derived. The amount consumed in the different fodders varied from 1030 to 1526 grams and the coefficients of digestion found varied from 37.37 in the saltbush to 65.15 in the alfalfa. If there is any relation between the digestibilty of the furfurol and the value of the hay it is a very general one. The merits of the six fodders used in this study were as follows: Alfalfa, very decidedly the best, corn fodder and native hay standing next, timothy hay next, with the sorghum and saltbush standing far behind the others. The coefficient of digestion of the furfurol in these fodders was found to be as follows: Alfalfa, 65.15, native hay 50.97, corn fodder 47.07, timothy hay 50.13, sorghum 46.46 and saltbush 37.37 per cent. A study of the amount of furfurol removed by the successive treatments to which the hays and fodders were subjected establishes the fact that they deport themselves somewhat differently, the saltbush showing the same amount, relatively, after as before extraction with alcohol, while the other samples showed a decided loss. That extraction with cold water should remove a little furfurol would be expected, provided the material removed and susceptible of inversion is really due to gums. We, however, find that it is uniformly small, as is also the case with the hot water and malt

extract. The two reagents that remove the greater portions of the furfurol are the hydric chlorid and sodic hydrate, but the cellulose often contains as much as either of these. The distribution of the furfurol in the various extracts of alfalfa, the saltbush and corn fodder, may be restated to make clear these differences.

TABLE XCIX.

	Alfalfa Grams	Corn Fodder Grams	Saltbush Grams
Furfurol soluble in 80% alcohol	144.5	1341.4	0.0
Furfurol soluble in 1% hydric chlorid	202.4	590.3	428.0
Furfurol soluble in 1% sodic hydrate	218.2	316.3	315.0
Furfurol remaining in the cellulose	256.2	162.9	400.0*

§163. These results point to very great differences in the properties of the compounds yielding the furfurol. A further study of the different tables will be seen to indicate that the leaves and stems are very different in this respect.

§164. The coefficients of digestibility as indicated by the results obtained point to further differences. We have for the coefficients for the furfurol in the above extracts the following:

TABLE C.

	Alfalfa	Corn Fodder	Saltbush
Soluble in alcohol	96.50	94.80	0.0
Soluble in hydric chlorid	100.00	73.17	Apparently None
Soluble in sodic hydrate	27.18	31.82	46.35
Retained in the cellulose	72.62	32.57	26.49

§165. The coefficient given for the digestibility of the furfurol in the cellulose of the saltbush includes the portion removable by treatment with chlorin, etc. It will be recalled that, in the case of the saltbush, the group which we designate crude fibre has an exceedingly low coefficient of digestion, 15.35 being the highest obtained with either of the sheep.

§166. We will see later that the significance of these differences are quite important. The testimony of the scales in regard to the live weight of these animals is that the alfalfa is an excellent fodder, that the corn fodder is good and that the saltbush is a very poor one. I am fully aware of the importance attached to the nitrogenous substances present in a fodder in the theories of animal nutrition, but the results so far obtained in this experiment, as I interpret them, point clearly to the equal importance of the character of the carbohydrates in the fodder.

§167. The amount and distribution of the proteids in the fodders and their respective extracts have already been given, but we

*This includes the portion removable by chlorin in the above extracts.

bring them together for the three fodders that we have tried to study a little more fully than the others, *i. e.,* alfalfa, corn fodder and the saltbush, *Atriplex argentca.*

TABLE CI.

	Alfalfa	Coefficent of Digestion	Corn Fodder	Coefficent of Digestion	Saltbush	Coefficent of Digestion
The crude proteids consumed	1817.15	72.92	472.82	37.74	1646.10	66.21
Soluble in 80% alcohol, consumed	594.41	81.69	215.76	65.49	629.40	87.91
Soluble in hydric chlorid, consumed	125.66	59.84	70.07	39.43	105.30	43.50
Soluble in sodic hydrate, consumed	851.70	81.89	98.98	0.00	538.90	70.10
Soluble in chlorin, etc., consumed	39.58	0.00	28.82	46.46	218.00	29.13

§168. We have here very grèat differences and, if we were to draw conclusions and base them upon the analytical results in regard to the quantity and digestibilty of the proteids present, we would certainly place the saltbush quite close to the alfalfa, but the results of the feeding, expressed in gain or loss of live weight, places the corn fodder far above the saltbush with a gain of 3½ pounds of flesh as against a loss of 8½ pounds or a total difference of 12 pounds live weight. It is only just to add that 6 pounds of the loss chargeable to the saltbush was made by one of the three animals, but even if this be due to the individuality, idiosyncrasy perhaps, of the animal, it suggests that the saltbush may be a bad fodder for many sheep, unless we were unfortunate in getting the one out of many among the three chosen with which it would give particularly unfavorable results. I have elsewhere referred to this possibility and have pointed out that the aggregate loss of the two that did not lose such an exceptional weight, was 2½ pounds, while those fed on corn fodder gained 3½ pounds, so that after assuming that the third sheep receiving the saltbush was so sensitive to its action as to render this sheep wholly unfitted for use in the experiment, the results obtained with the remaining two indicate that this plant is not fitted for a forage plant. The corn fodder, so far as the proteids are concerned, is not so good as the saltbush, but if we consider the carbohydrates as indicated by the sugars obtained in the inverted solutions, or by the furfurol obtained, and their coefficients of digestion, the corn fodder would appear to be much the better of the two, and this is the fact. This view of the importance of the carbohydrates will receive some confirmation when we briefly review the energy supplied by these three fodders and their extracts.

§169. The methoxyl group occurs in all of the fodders, but it is not very abundant, and its coefficient of digestion is low.

§170. The amid nitrogen is not abundant in these hays but its coefficient of digestion is high. How much energy it may yield in its changes either absolutely or in comparison with the albumenoids, I do not know.

§171. Perhaps the most suggestive results are those obtained with the bomb calorimeter. The percentage of heat which disappears from the fodder in its passage through the animal, varies with the different fodders; for the saltbush we found that 39.16 per cent. of the energy had disappeared; for the corn fodder 56.00 per cent., and for the alfalfa 62.43 per cent. In studying the respective extracts, the results agree in showing that the alcoholic extract furnished the largest amount of heat. Next to this in the case of the alfalfa and the saltbush comes the sodic hydrate extract, but in the corn fodder, the residue or cellulose furnishes the second largest quantity. The third largest quantity is furnished in the case of the alfalfa and saltbush by the cellulose and in the corn fodder by the hydric chlorid extract, as shown by the following statement of the heat units appropriated by the sheep from the respective portions:

TABLE CII.

	Alfalfa	Corn Fodder	Saltbush
Alcoholic extract yielded	10,737,717	7,027,781	5,781,962
Sodic hydrate extract yielded	8,218,319	2,146,018	5,502,520
Hydric chlorid extract yielded	2,999,157	4,914,158	4,037,125
Residue or cellulose	5,952,562	5,435,160	4,372,314

§172. These results are quite consonant with those obtained from the study of the extracts which show that the respective fodders yielded the following quantities of digestible material in grams:

TABLE CIII.

	Alfalfa	Corn Fodder	Saltbush
Alcohol extract	2520	1789	2515
Hydric chlorid extract	912	1245	1274
Sodic hydrate extract	1359	342	1040
Residue	1442	1210	841

§173. The fuel value of these different portions are not equal and the coefficients of digestion are also unequal, so that a close agreement could not be expected. The general deportment of the timothy and native hay would seem to place them close to corn fodder. The sorghum shows a large amount of digestible alcoholic extract, hydric chlorid extract and cellulose, but less of the latter two than the corn fodder and though they seem to be large enough in quantity and fairly proportioned, the sheep lost weight amount-

ing to almost three pounds each while being fed on this sorghum fodder.

§174. The amount of residue or cellulose digested in the various trials, the comparative uniformity of the coefficient of digestion and fuel value, indicate a very considerable food value for this portion of the fodder. It is the only portion of the saltbush that was not digested in the usual quantity. The general coefficient obtained for the crude fibre was only 8.29 in which is included the portion soluble in chlorin. When we consider the fuel value of this cellulose, it is higher, by a little, than that prepared from the other fodders, but the coefficient of digestion is very low, only 32.51 per cent. But it is higher than the coefficient found for the crude fibre of this hay, in fact it does not agree at all, except in that it is much lower than the coefficients which we found for this portion of the other fodders. The energy of the saltbush is, in general, low. The amount of water drunk was large and the animals were permitted to drink whenever they wished to. These two things may have interfered with the digestion of the cellulose, *i. e.*, there may not have been enough energy available to effect its breaking up and to carry on the other bodily functions.

DISCUSSION OF RESULTS AND RECAPITULATION

§175. In Bulletin No. 39 of this Station, I attempted to find some way to examine a fodder which would give us more satisfactory information regarding the value of the fodder than the old method furnished. I designated it as "A Study of Alfalfa and Some Other Hays". It is now ten years since that bulletin was published and I here present a brief review of the further work done in this line, extending it very materially to include the distribution of the nitrogen in the different extracts and also that of the pentosans. Further the determinations of the fuel value of the fodders and residues obtained by exhausting the fodders with different menstrua and therewith the energy value of the extracts themselves have been added.

§176. The analytical work has been supplemented by digestion experiments made with sheep, using three individuals in each experiment. When I commenced this portion of my study, I scarcely hoped to be able to carry it to the extent that it has been carried; had I foreseen the end, I would certainly have collected the urine and included this factor in the work, but even then the work would have been incomplete, though it would have been a little more satisfactory than it is at present.

§177. It is not expected that everybody will find interest enough in this subject to lead them to read all of the analytical results to see what errors have been made, and to weigh the force of each individual result obtained, so I may be pardoned for giving, in the form of a recapitulation, a general statement of the work.

§178. The fodders studied are alfalfa hay, timothy hay, native hay, saltbush hay, *Atriplex argentea,* corn fodder and sorghum fodder.

§179. It seems superfluous to state that we used the best quality of these different fodders that we could obtain. The alfalfa was probably rather old when cut and the hay had been preserved in a stack, so that some of it was not in prime condition, but, with these two reservations, it would be classed as very good hay.

§180. The timothy hay was grown in the mountains and was as good a quality as we could obtain. The native hay was, as is all the hay to which this name is applied, a mixture of grasses and sedges, and the results obtained with one sample of it will apply only in a general way to any other sample.

§181. The saltbush, *A. argentea*, was included in this study mainly because we need a plant to use in the eastern portion of the State as a forage plant. Irrigation is out of the question in this

section of the State, and the rainfall is so light that ordinary forage plants do not furnish much forage, if they succeed in living. This saltbush grows abundantly some seasons and in some places, and the ranchmen have cut it, made it into hay and used it to feed their stock during severe storms when the cattle were unable to graze on the plains, and needed something to enable them to endure the storms which, I understand, are often severe, being accompanied by low temperatures and high winds.

§182. I do not know that anyone has observed the effects of this fodder under any conditions, favorable or otherwise, so that our observations and results will be of commercial interest to this section of the State whether they are favorable or not. Further, the saltbushes have not been studied, not even the Australian saltbush, *Atriplex semibaccata,* which is a very different and, as a fodder, I hope, a much more valuable plant than this. It has, at least, been recommended by the California Experiment Station and in a preliminary feeding experiment made by myself it promised to be a fair fodder even when fed alone.

§183. I desired to study the composition, digestibility and feeding value of this class of plants, so this native saltbush which had already been used as a substitute for our better known forage plants, seemed to me to be a subject which would answer my purpose very well indeed, and might possibly be of considerable benefit to the State. I regret that my results do not justify any hope of adding a good forage plant in this indigenous saltbush. As a subject for the study of the questions discussed in this bulletin, however, it serves my purpose very well, for it proves to be a very poor fodder, one scarcely fit to be used under any circumstances and certainly not fit for use under conditions of stress and with cattle already reduced in vitality by continued exposure and lack of a generous supply of food.

§184. This fodder probably contains nothing positively poisonous or injurious, it is simply deficient as a fodder. One of the three sheep experimented with lost only one-half pound but another lost six pounds. We will later try to point out wherein it is deficient. None of the fodders studied serve better than this saltbush to make clear our principal object in this work, *i. e.,* to discover, if possible, what causes the difference between fodders—why one is a good fodder and another a poor one—to discover some way of judging correctly whether a fodder is good or poor without having to feed it, but this is after all, a comparatively convenient, rational and conclusive method and the results obtained by it need no summing up except as to cost.

§185. The other fodders studied were corn fodder and sorghum fodder. The results obtained with these fodders, particularly

in feeding them, were wholly unexpected,in that the former gave better results than was anticipated and the latter very unfavorable ones, which was contrary to what I had expected. Even now, I am scarcely content to accept the results of our feeding experiment. As will be seen subsequently, there is nothing in the composition, judged either by the regulation fodder analysis, or by what I have called the proximate analysis, or in its fuel values to suggest an inferior value for this sorghum fodder, but each of the three sheep fed on this fodder lost very nearly three pounds in five days during which time they not only consumed but digested a very fair amount of food, three pounds per hundred weight of animal daily.

§186. Our object was primarily to study the fodders to find out how we might learn more about the reasons why fodders are so different in value. The groups into which we have been accustomed to divide fodders are not definite groups, but are the best that we have had and they have not yet been displaced. Students have long felt that the results left much to be desired and have adopted other methods of investigation, in order to find out the value of the fodders, their composition, the heat values of the components, and the energy actually furnished to the animal.

§187. It occurred to me that an endeavor to study the carbohydrates might add something to our present knowledge and I chose the line of work presented in Bulletin No. 39, but I realized that it was only an attempt and left much that was unsatisfactory. Some of the results were not concordant and the work was not carried far enough and was not accompanied by any results obtained by these lines of examination in combination with feeding tests, the results of which should serve as facts on which to base our interpretations. I have tried to obviate these faults in the investigation now presented.

§188. I have adhered to the general line of experimentation outlined in Bulletin No. 39, so that the present work may properly be considered a continuation and extension of that. The general method of examination was to exhaust the fodders with boiling 80 per cent. alcohol, cold water, boiling water and after cooling with malt extract, boiling 1 per cent. hydric chlorid, boiling 1 per cent. sodic hydrate, and lastly, with chlorin, subsequently washing with 1 per cent. sodic hydrate and hydric sulfite. I have not yet seen any good reason for changing this order of procedure. The results show, however, that it does not effect a division of the fodder into any definite groups. By this I mean that the extracts consist of mixtures of substance whose composition cannot be established in this way. I hoped, for instance, to be able to determine the sucrose in the alcoholic extract, but I find from the determinations of the furfurol removed from the fodder, that it is quite probable that the

alcoholic extract contains pentosans which may yield reducing sugars on heating with dilute acids, or inversion, so there is doubt whether sucrose, ordinary cane sugar, in a fodder can be determined in this way, especially when present in small quantities. The same is true of the starch determinations, because we found that boiling for one hour and treating with malt extract removed furfurol as in the preceding instance. This shows that the pentosans are dissolved by a considerable range of solvents. Further, we find them present in all of the extracts except possibly that obtained by the treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid to remove the products of chloridization. Some furfurol is removed from the crude fibre by this treatment but we did not find any reducing sugar in the extract obtained; it is, of course, possible that the action of the chlorin was so drastic that it oxidized and radically changed the furfurol yielding substances so that there remained no hydrolizable carbohydrates of this type in the extract. The residue left, after all these treatments, the cellulose yields from 1.6 to 2.1 per cent. furfurol, showing that substances yielding from one-sixth to one-third of the total furfurol yielded by the fodder, resist all of these treatments and constitute a portion of the cellulose thus obtained. This is probably oxycellulose which may be the source of the furfurol removed by the treatment with chlorin and the subsequent washings.

§189. Again, we find that the nitrogen content of the fodder is distributed unevenly throughout the extracts, some of it, a very little, escaping all of the solvents and remaining in the cellulose. The compounds corresponding to the amid-nitrogen are quite easily soluble and might readily pass into the 80 per cent. alcohol solution but we find in the case of the alfalfa, for instance, that one-third of the nitrogen, calculated as proteids, is soluble in this menstruum, whereas, the amid-nitrogen, provided it were wholly soluble in 80 per cent. alcohol, could not constitute more than one-fifth of the total, showing that large amounts of nitrogenous substances other than amids went into solution. These statements will suffice to make clear the meaning of the assertion that this procedure does not effect the division of the fodder into well defined groups, and it was not expected that it would, but rather that it might enable us to find differences between the fodders which would at least help to explain the differences observed in their feeding values.

§190. It is and has been known, for the past twenty-four hundred years, that alfalfa hay is a good fodder, so there is nothing new in such a statement. The new thing is the general recognition of the fact and the interest taken in it. I have acknowledged this very generally accepted estimate of the value of this fodder in choosing it as the standard of comparison in this work. It may

not be a good standard for the comparison of all hays, as only a few of our hays are made from this class of plants, *i. e.*, the pea vine, the clovers, etc., even in my work it stands alone, a leguminous hay, though pea vine and red clover hay were included in the work presented in Bulletin No. 39. As a standard of value for different hays made from grasses it may not be a good one, but as a standard of value in this study no better one could, in my opinion, be adopted. It is a favorably known fodder, yielding good results wherever used and its use is rapidly becoming more extensive than heretofore. The results of our investigation of this hay show the following points of interest: But little danger in its use, the green plant may produce bloating in cattle and the feeding of musty and dusty alfalfa hay is charged with producing the heaves in horses, further when fed alone it produces looseness of the bowels and increased urination. These are the evils chargeable to this plant; the rest to be said is favorable, it being an excellent fodder, even for horses when fed with proper precautions, while for fattening cattle and sheep it is unexcelled. For these good reasons, I have chosen it as the first subject for study.

§191. The average composition of this hay is now very generally known; it is characterized by the presence of a high percentage of nitrogen, commonly expressed in terms of crude proteids which usually range from 12 to 15 per cent. of the hay. The group indicated by the term crude fibre is rather abundant, being from 30 to 35 per cent. in good hays, and that understood by the term nitrogen-free extract, is about the same, 30 to 35 per cent. In a general way, then, we may represent alfalfa hay as being composed of one-third crude fibre, one-third nitrogen-free extract, one-sixth proteids while the other sixth is represented by ash and ether extract. The other leguminous hay, common in some parts of Colorado, is pea vine hay. This is, when cut in full bloom, somewhat richer in proteids, with about the same, perhaps a little smaller, percentage of crude fibre and nitrogen-free extract. Red clover hay is occasionally met with and is, so far as the observations of this department go, something richer in nitrogen-free extract, but otherwise about the same as alfalfa. The leguminous hays differ from those made from grasses in that they contain less nitrogen-free extract, 30 to 36 per cent., in samples of alfalfa, third cutting, occasionally as much as 41 per cent., against 42 to 50 per cent. in the hays made from grasses. They are richer in crude fibre, ranging from 32 or 33 to occasionally 40 per cent. for alfalfa against 20 to 30 and sometimes more in the hays of the grasses. They further contain from two to three times as much crude proteid—from 11 to 17 or 18 per cent. against 5 to 9 per cent., rarely more, in that made from the grasses. Such are the differences between the two

classes of hays as shown by the ordinary fodder analyses.

§192. The differences between the hay of leguminous plants and that of grasses is further shown by the large portion removed by simple solvents such as water and alcohol. The total amount dissolved out of the air-dried hays by 80 per cent. alcohol and water in the order followed in this work is for alfalfa, 40 per cent.; red clover hay, 35 per cent.; pea vine hay, 34 per cent.; timothy hay, 31 per cent.; native hay, 30 per cent.; corn fodder, 37 per cent.; sorghum, 47 per cent., and the saltbush experimented with, 28 per cent. The 80 per cent. alcohol extracts from these air-dried fodders and hays, the following amounts: From alfalfa, 27 per cent.; corn fodder, 29 per cent.; timothy hay, 21 per cent.; native hay, 21 per cent.; sorghum, 36 per cent., and from the saltbush hay, 22 per cent. A quantity of alfalfa was digested with cold water for 24 hours and the loss then determined, when it was found to be 40 per cent. Apparently then, water alone will remove from alfalfa as large an amount of extractives as alcohol and water when used successively; this was not established by repetitions of this experiment. No precaution was taken against fermentative changes. This result is consonant with the well known susceptibility of alfalfa to injury by moisture, even a heavy dew sufficing to discolor it. I did not submit the hay to the ordinary fodder analysis after treating it in this manner. The results would doubtlessly have been interesting if I had done so, but I have an old analysis of a hay damaged by a succession of showers necessitating the exposure of the hay to both extraction and fermentation. Making no allowance for the large loss of weight, which must have been suffered in this case, we have the following difference in the hay as cut and gathered: Crude fibre as cut 26.46 per cent., as gathered 38.83 per cent.; crude proteid as cut 18.71 per cent.; as gathered 11.01 per cent.; and the nitrogen-free extract 38.91 per cent. as cut, and 33.64 per cent. as gathered. These results are affected by the mechanical losses as well as chemical, but they serve to suggest that it is not only an important consideration for the farmer but a good point of attack for the student of such subjects. The hays made from the grasses, and the native hay, being a mixture of grasses and sedges, may in this respect be fairly representative of such as are usually used in hay making, yield just about one-half as much to alcohol and water as the leguminous hays.

§193. The other well known class of fodders represented in our study is corn fodder. The dry matter of this fodder differs according to the ordinary fodder analyses from that of the leguminous hay in containing nearly one-half more nitrogen-free extract, and from one-third to one-half as much crude proteid, while the

crude fibre is not far from the same, though not nearly so constant, being sometimes more and sometimes less.

§194. The solubility of the nitrogenous substances of these different fodders in 80 per cent. alcohol may further exhibit their differences, as well as the extent to which these substances are soluble in this medium. The nitrogen has, of course, been calculated as proteids by multiplying by 6.25, the usual factor. The following table gives the weight in grams of the proteids in the fodders fed, and the amount which was soluble in the respective solvents.

TABLE CIV.

	Alfalfa	Corn fodder	Timothy	Native hay	Saltbush
80% alcohol	640.0	249.0	189.0	231.0	692.0
Cold water	91.0	33.0			57.0
			83.0	70.0	
Hot water and malt	135.0	27.0			108.0
1% hydric chlorid...	127.0	79.0	99.0	98.0	133.0
1% sodic hydrate ...	937.0	116.0	350.0	384.0	618.0
Chlorin	45.0	30.0	13.0	29.0	236.0
Residue or cellulose.	17.0	6.0	9.0	11.0	29.0
Total proteids fed ..	1992.0	540.0	743.0	823.0	1873.0

§195. We see that the two hays, timothy and native hay, yield between one-quarter and one-third of their nitrogen to the alcohol, which is nearly as high a ratio as in the case of alfalfa and the saltbush. The maximum relative portion is observed in the case of the corn fodder in which the amount dissolved amounts to nearly one-half. There is either no relation between the soluble nitrogen and the value of the fodder, or it is so greatly modified by other factors that it is entirely concealed. Of these fodders, alfalfa produced the largest results, *i. e.*, 9 pounds of flesh in five days; the corn fodder and native hay next with 3½ pounds each; the saltbush and sorghum last with a loss of 8½ pounds each.

§196. The amount of nitrogenous matter dissolved out of the hays by water, after previous treatment with the 80 per cent. alcohol is very small, but the loss of the alfalfa hay which has been exposed to the rains suggests, at least, that the nitrogenous matter soluble in the alcohol may also be soluble in water. Be this as it may, neither cold or boiling water removed any very considerable portion after the previous treatment with alcohol. The two exceptions to this are the saltbush and the alfalfa. We also notice that it is these two, saltbush and alfalfa, from which the 1 per cent. hydric chlorid removes the largest quantities of the proteids, that is, absolutely but not relatively, for in the alfalfa, for instance, about one-sixteenth of the nitrogen is dissolved out by the 1 per cent. hydric chlorid, while in the corn fodder and timothy hay it is about one-seventh.

§197. The similarity between the alfalfa and the saltbush in regard to the amount of proteids present and their solubility in these solvents is striking and two things regarding them is very evident, *i. e.,* while one-half of the proteids were removed from the alfalfa by the 1 per cent. sodic hydrate, only one-third of them was removed from the saltbush, but the amount removed by chlorin and subsequent washing with 1 per cent. sodic hydrate and hydric sulfite is five times as great. The relative quantities, owing to the fact that the quantities fed were so nearly alike, are the same, *i. e.,* one-fortieth and one-eighth respectively. The nitrogenous substances removed by the chlorin and the subsequent washings usually amount to but a few grams and are apparently often more abundant in the feces than in the hay or fodder, but in the saltbush hay such proteids(?) are unusually abundant and they have a coefficient of digestion, according to our experiments, of about 29 per cent., which is, of course, very low. We evidently have to do with nitrogenous substances quite different in character and while our division of them into groups is not satisfactory, we still have three big groups; those removed by 80 per cent alcohol, always with a good or even high coefficient of digestion; those soluble in hydric chlorid differing very much in their digestibility, from 39 to 63 per cent. in the different fodders, and those soluble in sodic hydrate which have high coefficients of digestion, except in the case of the corn fodder in which this group of nitrogenous substances is not nearly so large as in the other fodders and is, apparently, so good as indigestible. The proteids soluble in cold and hot water are not considerable in quantity, except in the alfalfa and saltbush, and are not very digestible, while those removed by chlorin, etc., are small in quantity, except in the case of the saltbush, in which they constitute an eighth of the total, and either show a low coefficient of digestion, 29 per cent. in the case of the saltbush, or are more abundant in the feces than in the fodder fed.

§198. What the bearing of these facts may be on the feeding values or properties of the fodders is not clear.

§199. It may be well to consider some facts, as well as we may, but without assuming that we know anything about them. The alfalfa and saltbush, for instance, constitute the extremes in our series of fodders, perhaps I should, to be logical in interpreting our results, class sorghum and saltbush together. As already stated, I cannot but entertain a strong opinion that the sorghum should be studied further, because of the very unfavorable results obtained. It must, however, be acknowledged that the results in the case of the three sheep were uniform and unfavorable, though the fodder was apparently of excellent quality and in very good condition. The results showed a loss of almost three pounds in each of

the three sheep, which certainly ought to have more weight than my opinion that the sorghum is a better fodder than these results indicate. We did not make as full a study of the sorghum as of the other fodders and for these two reasons I have less to say about the sorghum than about the others.

§200. With this explanation regarding the sorghum, I will consider the saltbush as constituting the most inferior fodder of the series, and yet, as stated before, this fodder is richer in proteids than either of the remaining five, alfalfa alone excepted. With the alfalfa, we fed, in round numbers, 2,000 grams of proteids, coefficient of digestion 72.5, with the saltbush practically 1,900 grams, coefficient of digestion 66.4. The three sheep fed on alfalfa gained 9 pounds, those fed on saltbush lost 8½ pounds. It is, of course, wholly improbable that other constituents had no disturbing effects on the results, but it is also very probable that the nitrogenous substances soluble in the different reagents are of very different value and it is not the amount of the proteids (N x 6.25) present, but their character which determines their value. It may be that the large amount of chlorin-soluble nitrogen present in the saltbush, constitutes not only an analytical difference, but a nutritive one also. It is evident that the sheep digested rather more proteids when fed on alfalfa but the difference is not very big, 239 grams. The amounts of proteids digested where corn fodder was fed were quite small, less than one-fifth of that digested in the case of the saltbush and one-sixth of that in the case of the alfalfa. The amount digested when native hay was fed was less than one-half of that digested in the case of the saltbush. Both the native hay and corn fodder proved to be good fodders, all of the sheep gaining while receiving them; the aggregate gain in the two lots of three sheep each, was three and one-half pounds for each lot.

§201. The animals were not fattened on these fodders and killed to see the relation of muscle to fat, so I do not know anything about this feature of their effects. The amount of the alcohol-soluble proteids in the corn fodder is larger than that in any of the other solvents, being 217 grams out of a total of 473 grams. In the case of the native hay the two solvents removing the largest quantities of proteids are the sodic hydrate and alcohol. The contrast in the results produced in these experiments is that the sheep receiving saltbush digested 1,091 grams of proteids and were losing flesh, some of them rapidly; those receiving the other fodders were gaining, though they received much smaller amounts of proteids with either the corn fodder or native hay and only 239 grams more when fed alfalfa, but in this case the lot made a gain of nine pounds against a loss of 8½ pounds in the lot receiving saltbush.

§202. The question which I have tried to present is, do the

facts exhibited by the results of this proximate analysis offer any suggestions regarding the reasons for so great a difference in the feeding values of these fodders.

§203. We will later give a reason for the assertion that the alcoholic extract is the most important portion of the fodder and we observe that the proteids of the saltbush, soluble in alcohol and digestible, is greater even than in alfalfa, so that it would seem probable that this portion of the saltbush, unless it should contain some therapeutically active and deleterious substance, is probably the most valuable portion of this fodder, but if the fuel values are safe criteria, it is of comparatively small value compared with that of the corresponding alfalfa extract, giving a little over one-half the energy. This, of course, applies to the whole extract from which we cannot single out the effect of the nitrogenous matter.

§204. The carbohydrates in the alfalfa and the saltbush are evidently quite different; if we take the total sugars as the measure, they stand as 9 to 26, there having been fed with the alfalfa, carbohydrates capable of giving 900 grams of sugars, while the saltbush gave 2,600 grams. The furfurol also indicates a great difference. There was consumed with the alfalfa 1,030 grams of furfurol and 1,524 grams with the saltbush. The coefficient of digestion for the furfurol in the alfalfa was 65.2, and for that in the saltbush 37.4. The weight of alfalfa fed was 13,351 grams, and of saltbush 16,088 grams. The difference in the coefficients of digestion is also very marked, 37.4 in the case of the saltbush and 65.2 in that of the alfalfa. The difference in the character of the carbohydrates is still further indicated by the low degree of digestibility shown by the residue, which I have for convenience sake called cellulose, which is 29 for that from the saltbush and 53 for that from the alfalfa. The action of chlorin, together with the subsequent washing with sodic hydrate and sulfurous acid does not show as great a difference in these cases as in that of some other fodders, though the amount removed from the saltbush is the greater by about 1.6 pounds per hundred. This portion of the fodder seems to be uniformly very difficult of digestion, the coefficient in the case of the saltbush being but 6.3. I have elsewhere suggested that the low coefficient uniformly obtained for this portion of the fodder may be apparent only, due possibly to a close resemblance between it and fecal matter, as we have found this portion in the feces larger than the total fed in several instances. The hydric chlorid with which the fodders were boiled till no more sugars were produced, also shows a decided difference. The alfalfa consumed, 12,364 grams, yielded but 340 grams of sugar, calculated as galactan, whereas the 16,088 grams of saltbush yielded 1,455 grams of sugar calculated as xylan; here again the coefficients of digestion indicate wide difference of proper-

ties. The alfalfa sugar, galactose, shows a coefficient of 84, and the saltbush sugar, xylose, a coefficient of 58.6.

§205. The nitrogenous substances may contribute a small proportion of these sugars, but they undoubtedly are, for the most part, derived from other compounds.

§206. The difference in the coefficients of digestion for the respective residues becomes still more significant when it is called to mind that this residue is one of the three important portions of the fodder, as will be more fully shown under the discussion of their relative heat values. We will find that the coefficients of digestion, 53 for the residue from the alfalfa and 29 for that from the saltbush, are not consonant with the heat values obtained, but still we will see that they are nearly so and that the saltbush residue yielded less than three-fifths as much energy per unit of weight as that from the alfalfa.

§207. The corn fodder was found to be a good fodder, producing a gain of 3½ pounds in the three sheep. There was digested by the sheep in this instance 4,940 grams of dry matter, equal to 56.3 per cent. of that consumed, 1,789 grams of which was soluble in alcohol, 1,245 grams soluble in hydric chlorid, and 1,210 insoluble.

§208. In this case the sugars indicate the presence of a large portion of alcohol-soluble carbohydrates, glucose and cane sugar, together amounting to 872 grams, which is wholly digestible, and 975 grams in the form of galactan and xylan, sugars inverted by the action of the dilute hydric chlorid; these practically constitute the whole of this class of substances in the corn fodder, as cold water, hot water and sodic hydrate together remove but 100 grams of sugars from the whole amount of corn fodder consumed; the cellulose is, of course, to be added to these to obtain the total carbohydrates. The furfurol removed by alcohol is very small in amount, so that while some pentosans are present the amount is at most, insignificant; 77.5 grams were consumed and the coefficient of digestion was found to be 94.8 per cent., so, aside from our knowledge of the fact that sucrose and reducing sugars occur in the juices of the corn stalk, there is no question but that the sugar found did not come from the inversion of other carbohydrates. The total amount of furfurol found to have been removed by hot water and malt seems to be open to question, as our duplicate determinations did not agree very well. The hydric chlorid extract furnished very nearly one-half of the sugars found and a little more than one-half of the furfurol found in the extracts of the fodder; this, of course, does not include the residue or cellulose.

§209. The amount of proteids consumed with the corn fodder was much less than in the other two instances, alfalfa and saltbush. With the alfalfa 1,817 grams were consumed and 1,325 digested;

with the saltbush 1,646 grams were consumed and 1,090 grams digested; but with the corn fodder there was only 473 grams of proteids consumed and 179 grams digested. This fodder seems to give favorable results, though the composition of the fodder is very different from the others in respect to the amount and character of the carbohydrates and also in regard to the proteids, the latter, in particular, being largely soluble in the 80 per cent. alcohol. This is especially noticeable with the portion digested, as 141 grams out of the 178 digested were soluble in the alcohol. Another point of difference between the proteids of these three fodders is the low degree of digestibility of the proteids contained in the corn fodder. This is true with both the general coefficient and the coefficients obtained for the proteids in the extracts. The general coefficients of digestibility for the proteids are 73 for those of the alfalfa, 66.4 for those of the saltbush, and 36 for those in the corn fodder. Alcohol dissolves approximately one-third of the total proteids out of alfalfa, and these have a coefficient of digestion of 81.7; from the saltbush a trifle more than one-third, and the coefficient of digestion was found to be 88; from the corn fodder, it dissolves a little less than one-half of the nitrogen, calculated as proteids, of which 65.5 per cent. was found to be digestible.

§210. The other solvents removed quite small amounts of proteids from the corn fodder and these have quite low coefficients of digestion. The sodic hydrate dissolves the second largest portion of the proteids out of the fodder, but it is so good as indigestible. This is in marked contrast with the other fodders, in which cases the amounts of proteids dissolved out by the sodic hydrate are both absolutely and relatively much greater, and the coefficient of digestion is high in each case, 82 for that of alfalfa and 70 for that of the saltbush, against zero for that of the corn fodder. It is possible that the coefficient obtained for this portion of the proteids is erroneous, but it is not probable, and it is safe to assume that the coefficient of digestion of this portion of the proteids in corn fodder is very low, indeed, probably zero, as above stated.

§211. The most notable features so far developed are that the soluble carbohydrates, *i. e.,* all that portion of the fodders not included under the proteids, and the residue or cellulose vary within narrow limits, except for those soluble in hydric chlorid. The most important extract is that obtained by alcohol, in which, it is true, that large quantities of proteids occur, but their coefficient of digestion is, in the cases of the saltbush and corn fodder, less than the general coefficient for the extract, so that the coefficient for the carbohydrates must be higher than that found for the extract. This does not hold for the alfalfa. The coefficients of digestion found for the alcoholic extracts of these three fodders are as follows—alfalfa,

68.6; saltbush, 70.5; corn fodder, 73.8. We see that they are quite close together, and as the percentage of the respective fodders soluble in alcohol are not very unlike, it seems just to assume that in the absence of any injurious constituent they have approximately the same value, but such is not the case, as is indicated by the heat values appropriated by the animals, according to which the relative values of the three alcoholic extracts stand as 1 to 1.5 to 1.9 nearly. The alfalfa extract having a value of 1.9 and that of the corn fodder 1.5, if the saltbush extract be taken as 1. The second important division of the carbohydrates is represented by the hydric chlorid extract and here we find very great differences indicated by the coefficients of digestion. This portion of the alfalfa has a coefficient of 60.2; that of the corn fodder 69.4, while that of the saltbush has a coefficient of only 39.9. The percentage of this portion present in these fodders was found to be as follows: Alfalfa, 12.2; corn fodder, 18.9, and saltbush, 17.0. We observe that the coefficient of digestion for this group of substances in the saltbush is low and the percentage of it present in the hay is high, from which standpoint it would be an important factor in judging of the value of the fodder. The coefficients of digestion found for the corresponding heat values were, for the alfalfa, 54.75; for the corn fodder, 63.88, and for the saltbush, 40.7. The indication of these coefficients, too, is that this portion of the saltbush extract is inferior to that of the other two. The heat appropriated by the sheep per gram of this extract consumed, stood in the ratio of 1.3 to 1.8 to 2, the saltbush again being the lowest and the alfalfa the highest. The deportment of the proteids present in these different fodders has been referred to in a previous paragraph, where it is shown, though not explicitly stated, that the proteids in the saltbush resemble those of the alfalfa in their quantity and deportment toward the different solvents, so here we find the proteids in the alcoholic extract of the corn fodders relatively high and those of the alfalfa and saltbush relatively low, but the absolute amount of proteids in the hydric chlorid extract of the corn fodder is small and of no significance, while the actual weight of the proteids dissolved out of the alfalfa and saltbush, respectively, is much greater than in the case of the corn fodder, but it is not sufficiently large to materially modify the statements made relative to the value of the carbohydates represented by this portion of the fodder.

§212. The sodic hydrate extracts of the three fodders differ greatly; that from the alfalfa shows a coefficient of digestion of 67.7, but about 43 per cent of the total extract is proteids (N. x 6.25); that of the corn fodder is poor in proteids and has a coefficient of only 36.3, while that from the saltbush is richer in proteids, about 20 per cent. of the extract consumed being proteids, and has

a coefficient of digestion of 49, but that of the proteids contained in this extract is 70, so that the substances, other than proteids in this extract must have a low coefficient, which is consonant with the result obtained in the case of the corn fodder. The portion of this extract, sodic hydrate, having the greater value is probably the nitrogenous substance, while the carbohydrates possess the lesser value.

§213. None of our results are more instructive probably than those shown by the portion which resists the action of our solvents, even the chlorin followed by the caustic soda and sulfurous acid. We find that this residue from the alfalfa hay has a coefficient of digestion of 52.8, and that from the corn fodder a coefficient of 54.0 per cent. The boiling one per cent. solutions of hydric chlorid and sodic hydrate are pretty active agents, but moist chlorin is much more active, still the animal digestive processes effect the solution of upwards of 50 per cent. of the material in the good fodders, alfalfa and corn fodder, which has resisted these agents, while in the poor fodder, saltbush, these processes are capable of bringing only 29 per cent. of this residue into solution. It will be shown a little later that the heat values show a similar result.

§214. There is no evidence, that I have discovered, that the saltbush had any deleterious effect on the sheep, though I have been told that it acts as a laxative on cattle, and it did induce excessive thirst and urination in the sheep experimented with. There were no indications that the sheep were in the least uncomfortable. While the nitrogenous substances in this forage may be inferior in value to those in the alfalfa, there is no proof that they are. Two things are, however, clear—that they are much more abundant and have a much higher coefficient of digestion than those of the corn fodder; in fact, this fodder approaches the alfalfa in this respect more closely than either of the other fodders used in the experiment, and while I know nothing relative to the fuel value of the nitrogenous compounds, it may be assumed that the differences are not sufficient to completely reverse the indications given by the coefficients of digestion obtained for the proteids, according to which the saltbush should have a very much higher feeding value than the corn fodder, and nearly equal to that of the alfalfa. On the other hand, all of the data obtained indicate that the carbohydrates, whether soluble in the various menstrua or not, are difficultly digestible and, taken all together, are of low fuel value. This is particularly the case with the two important portions, the portion removed by hydric chlorid, 1 per cent. solution, and the cellulose or residue, the former having a coefficient of digestion of 39.9 and the latter of 29.0 per cent., as against 69.4 and 54.0 per cent., respectively, in the corn fodder. The factor in this fodder which seems to determine its feeding value is

the character of the carbohydrates that it contains. The nitrogenous matters contained in the saltbush are abundant and are highly digestible. The carbohydrates are resistant to the processes of digestion. The sheep digested large amounts of protein, 1,090 grams, but relatively small amounts of carbohydrates, and the lot lost 8½ pounds in five days. The results obtained with this fodder are in strong contrast with the other two; with the alfalfa the sheep ate and digested large quantities of both nitrogenous compounds and carbohydrates, both those soluble in hydric chlorid, 1 per cent. solution, and those which resisted the action of all of our solvents; with the corn fodder, they consumed a relatively small amount of nitrogenous compounds, having a low coefficient of digestion, 37.7 per cent., and a relatively large amount of carbohydrates with a high coefficient of digestion. The total amount of dry matter consumed as corn fodder was smaller than with any other fodder used, still each of the animals gained flesh, the lot gaining 3½ pounds in five days.

§215. The urine was not collected in any instance, an omission which is especially regretable in the case of the saltbush, because a large amount of nitrogenous matter was digested and there was a pronounced loss, especially with one of the sheep, 6 pounds. This is the only case in which we found marked differences in the individuals, but we did observe that one of the animals evidently did not like portions of the timothy, and while two of them lost a little, one gained a little, while on an exclusively timothy ration. With the other fodders, they either all lost or all gained. With the alfalfa they each gained three pounds, with the sorghum they each lost about three pounds, with the corn fodder and native hay they each gained, the total gain for each lot being three and one-half pounds.

§216. The other fodders, timothy hay, native hay and sorghum, were not studied to the same extent as those already given. Of these three, the native hay is the only one on which the lot made a gain; one sheep made a gain of one-half a pound on the timothy, but each of the others showed a loss, so that the lot showed a slight loss.

§217. As the same general result, *i. e.,* a gain of three and a half pounds in each case, was obtained with the corn fodder and native hay, we will present the salient points in the character of these fodders so far as we can; the alcoholic extract of the corn fodder furnished 1,789 grams of digestible matter, 73.79 per cent. of the total extract; that of the native hay furnished 1,297 grams, 58.55 per cent of the total; the hydric chlorid extract of the corn fodder yielded 1,245 grams digestible matter, equal to 69.42 per cent. of the extract; that of the native hay 1,422 grams, equal to 64.04 per cent. of the extract; the sodic hydrate extract of the corn fodder yielded

342 grams of digestible matter, equal to 36.27 per cent. of the extract; that of the native hay yielded 575 grams, equal to 32.79 per cent. of the extract; the residue or cellulose from the corn fodder yielded 1,210 grams of digestible matter, equal to 54 per cent. of the residue and that of the native hay yielded 1,502 grams, equal to 50.57 per cent. of the residue.

§218. In the case of the timothy hay, the values of the respective extracts stand in the same order, but the digestible matter furnished in each case, the sodic hydrate extract excepted, is less than in the two preceding cases; the alcoholic extract furnished 1,085 grams of digestible matter; the hydric chlorid extract 1,099 grams; the sodic hydrate extract 733, and the residue of cellulose 932 grams. The digestible proteids (N. x 6.25) in these extracts were determined; in the alcoholic extract there were 129 grams; in the hydric chlorid extract 23 grams, and in that obtained by means of sodic hydrate 136 grams. The digestible proteids in the corresponding extracts of the corn fodder were found to be 141 grams in the alcoholic, 28 grams in the hydric chlorid, and none in the sodic hydrate extract. We see again, in the timothy hay, as in the saltbush, that a larger amount of proteids were digested and a decidedly smaller amount of carbohydrates, the most marked deficiency being in the portion designated as residue or cellulose. The feeding results were a loss in both cases, though with the timothy hay, it was only slight, and one sheep showed a slight gain, but this sheep digested two-thirds more crude fibre than either of the other two. This may, however, be an accident only. The proteids in the various extracts of the native hay were not determined.

§219. The extracts of the sorghum stand in the same order as those of the corn fodder, and the amount of digestible matter contained in the alcoholic extract is much larger, nearly twice as large, but that furnished by the hydric chlorid extract and by the residue or cellulose, furnishes one-sixth less than in the case of the corn fodder.

§220. So far as our analytical results and also the energy values obtained are reliable criteria, sorghum fodder would appear to be a good one, but the results as indicated by the weights of the sheep at the beginning and end of this experiment indicate that it is a poor fodder. The results were uniform, *i. e.*, each of the sheep lost three pounds and the conditions of the experiment were as favorable as we could make them; everything, in fact, was in favor of obtaining good results with this fodder. The weather was fair and moderately cool. The sheep were used to being handled. They fed freely and were allowed a liberal ration, still they lost weight, and the same sheep gained when fed on corn fodder, so that the individuality of the sheep is eliminated so far as this comparison of

the corn fodder and sorghum is concerned. As I have elsewhere stated, any inferences from the analytical results or determinations of the fuel values and all personal opinion regarding the value of such sorghum fodder must be held in abeyance when the feeding results are so strongly against them.

§221. I do not know what the general judgment relative to the value of this fodder is, but Mr. Payne, who grew this sorghum, tells me that he and the party who joined him in his work with this sorghum, came to the conclusion that when fed alone it was of no value, which agrees with the results of my feeding experiments.

§222. The pentosans as represented by the furfurol show very marked differences. The four portions of the fodders which are of the most importance cannot be designated as in the case of the extracts, because they vary with each fodder. The alfalfa was beyond all question the best fodder experimented with, and we find considerable quantities of furfurol in each of the extracts made, but the three most important portions of the hay in furnishing digestible furfurol were the alcoholic and hydric chlorid extracts and the residue or cellulose. The sodic hydrate removed more furfurol from the fodder than any other solvent, but its coefficient of digestion is very low, 27.80 per cent., while the coefficient of digestion for the whole extract was high, 67.7 per cent. Cold water, hot water and malt extract and chlorin, with the subsequent washing with sodic hydrate and hydric sulfite, each remove some furfurol, but the quantities are relatively small and the coefficients of digestion vary greatly, which, owing to the relatively small quantities involved, is probably a matter of small importance. This class of substances, the pentosans, constitute about one-eleventh of the total dry matter digested by the sheep fed on alfalfa, about one-tenth of that digested as corn fodder and about one-thirteenth of that digested as saltbush, which is the smallest amount found in any of the six fodders.

§223. The fodders which stood nearest in value to the alfalfa were the native hay and corn fodder. This does not mean that they were nearly equal to it by any means, but the two fodders giving the next best results measured by the increase in the live weight. The lot receiving alfalfa gained nine pounds, while the lots receiving native hay and corn fodder, respectively, gained three and one-half pounds each. The lot receiving timothy hay lost one pound. The timothy and native hays are representative of the small grasses, as distinguished from the corn fodder, and are more nearly alike so far as the distribution of the pentosans is concerned than the native hay and corn fodder. From the smaller grasses, timothy and the native grasses, the largest quantities of furfurol are removed by the hydric chlorid and sodic hydrate. The next largest portion remains in the residue or cellulose. The coefficients of di-

gestion of the furfurol contained in the respective portions of these hays are very different. The furfurol removed by the hydric chlorid has a coefficient of 32.8 in the case of timothy hay, and 44.04 in the native hay; that removed by the sodic hydrate has a coefficient of 11.54 in the timothy and 42.16 in the native hay, and that remaining in the cellulose has a coefficient of 50.12 per cent. in the timothy and 74.94 in the native hay. The furfurol in some of the other extracts shows higher coefficients of digestion, but owing to the smaller quantities concerned are of less importance.

§224. The amount of furfurol in the cellulose is usually large. In the cellulose from the alfalfa, 235.7 grams; from the timothy, 197.1 grams, and from the native hay, 219.1 grams. The alfalfa and native hays proved to be good fodders, the timothy hay a poor one.

§225. The distribution of the furfurol in the different portions of the corn fodder agrees with that of the hays already mentioned, in regard to the hydric chlorid and the sodic hydrate extracts, but the cellulose shows less furfurol and it has a very much lower coefficient of digestion. In the case of the corn fodder, the hydric chlorid extract shows the largest amount of furfurol, 371.8 grams, with a high coefficient of digestion, 66.25. The sodic hydrate extract consumed contained 236 grams of furfurol, coefficient of digestion 31.82. The next extract in importance, as indicated by the furfurol, was the hot water extract, in which the furfurol was wholly digestible. I have very strong misgivings as to the correctness of this determination and, for this reason, have attached but little importance to it; if, as I surmise, there is an error in this determination, it will increase the relative importance of the hydric chlorid extract. This corn fodder proved as efficient as the native hay in results obtained, *i. e.*, a gain of 3½ pounds live weight in the lot fed, but this lot did not consume as much dry matter by 1,811 grams as the one receiving native hay. The general coefficient of digestion obtained for the furfurol in corn fodder was found to be 60.19 per cent., which does not agree with that obtained by taking the sum of the furfurol found in the different extracts, being about 12 per cent. higher.

§226. It will be observed that on three of these fodders, the respective lots of sheep gained, and on the other three the lots lost. I have already mentioned timothy hay as one in which the lot receiving it lost in weight. The other two were sorghum and the saltbush, *Atriplex argentea*. Regarding the distribution and digestibility of the furfurol, representative of the pentosans, we find that in the sorghum, the three portions, the hydric chlorid extract, the sodic hydrate extract and the cellulose, contain practically the whole of it, and that the furfurol shows the following coefficients of diges-

tion, 45.72, 25.44 and 48.72, respectively. In the saltbush we have to add the aqueous extract to the above. The alcoholic extract removed no furfurol or equivalent pentosan, but both glucose and sucrose were present and the extract was abundant, 3,197 grams of it having been consumed. The next salient feature in this connection is the low coefficient of digestion found for the furfurol, *i. e.*, 37.37; the pentosans extracted by the 1 per cent. solution of hydric chlorid are indigestible in this case, whereas it is highly digestible in the alfalfa and corn fodder and has a coefficient of 44.04 in the native hay. The coefficient of digestion for the furfurol in the cellulose of the alfalfa and native hay is 72.6 and 74.9, respectively, and is very low in that of the corn fodder, 32.57. There is no means of judging how much pith cellulose is represented in this corn fodder, and I know nothing about the deportment of this variety of cellulose. It is quite possible that this may have a noitceable influence on this result. In the three fodders which we find to be inferior or poor, timothy, sorghum and saltbush, we have low coefficients for the furfurol, the general coefficients being 36.24, 46.46 and 37.37, respectively, and for the furfurol in the cellulose 50.12, 48.72 and 26.49, respectively.

§227. I will again call attention to the fact that the cellulose obtained as the result of these treatments has, as a rule, a fairly high coefficient of digestion in those fodders which proved to be the best ones, in alfalfa 52.8, in corn fodder 54.0, in native hay 50.6, but lower in the other three, timothy, sorghum and saltbush, 41.6, 47.4 and 29, respectively. The digestible proteids in these fodders were in the alfalfa 1,325.09 grams, in the native hay 366.55 grams, and in the corn fodder 178.46 grams; these are the three fodders which caused the sheep to gain, the other three, timothy, sorghum and saltbush, caused them to lose. The following amounts of proteids were digested while the sheep were on these fodders, with the timothy 234.42 grams, with the sorghum 300.91 grams, and with the saltbush 1,089.80 grams, so that the loss is scarcely to be attributed to a lack of digestible proteids. The sheep digested almost as many grams of proteids with the sorghum as with the native hay and almost 1½ times as much as they digested in the form of corn fodder. They digested six times as much in the form of saltbush as in that of corn fodder, and while the one lot gained 3½ pounds on the corn fodder, the other lot lost 8½ pounds on the saltbush. My interpretation is that the differences in the results point to the absence of a sufficient amount of easily digestible carbohydrates in the timothy hay, sorghum and saltbush.

§228. I have in mind a little more definite idea when I use the term easily digestible than we sometimes have when we use this term. I do not simply mean that large quantities of the carbohy-

drates are taken up and a condition of comfort and general well being produced in the animal, but that the amount of energy necessarily used up in carrying on the animal functions while on the fodder and that used up in transforming the fodder constituents into forms which are assimilable by the animal are relatively small. In the case of the corn fodder, we observe better results with lower consumption of dry matter and energy than in the native hay—the two fodders producing the same results—while still larger quantities of both dry matter and energy were appropriated with the sorghum and saltbush, resulting in a loss instead of a gain. There was evidently more energy available for the production of flesh in the case of the corn fodder than in the two latter cases, though the total energy used up was less.

§229. We cannot present so full an account of the heat or energy relations of these fodders. We have determined the general values for all of the fodders, but have studied only three of them in detail. The amount of heat appropriated by the sheep from the respective fodders was as follows, given in small calories: Alfalfa, 30,955,663; sorghum, 25,088,621; saltbush, 23,149,533; native hay, 22,255,418; corn fodder, 19,424,180; timothy hay, 17,406,363 calories. We see that the energy appropriated by the animals does not stand in the order of the gain or loss. Alfalfa produced the greatest gain, and sorghum the greatest loss, with the saltbush very close to it. The native hay and corn fodder each produced a moderate gain, while the timothy produced a slight loss. As the urine was not collected, it could not be examined, and we do not know how much of the energy appropriated was voided in this form.

§230. The amounts of dry matter digested in the experiments with these several fodders were as follows: Alfalfa, 7,734 grams; saltbush, 7,351 grams; sorghum, 6,725 grams; native hay, 5,392 grams; corn fodder, 4,940 grams; timothy hay, 4,501 grams. We see that the order is the same as in the case of the heat or energy appropriated. The greatest gain, that made on alfalfa, agrees with the greatest amount of heat appropriated and the largest amount of dry matter digested, but the next two fodders on which gains were shown are not the next in the order of the energy appropriated or the dry matter digested, but form the fourth and fifth in this order, the timothy standing only about 2,000,000 calories below the corn fodder. The lot receiving the sorghum and appropriating 25,088,621 calories, showed a loss of 8½ pounds, and the one receiving the saltbush and appropriating 23,149,533 calories showed a loss of 8½ pounds, while that receiving timothy and appropriating 17,406,363 calories lost but one pound, and that receiving corn fodder and appropriating 19,424,180 calories gained 3½ pounds.

§231. It would seem then that it is not merely a question of the amount of energy that disappears or is appropriated, that produces the beneficial effects of a fodder, but that these may depend upon other factors, for instance, the amount of energy used up in the process of digestion. We have in the case of the corn fodder favorable results with smaller quantities of material than with any other fodder. We have 4,940 grams of dry matter digested which contained 178.46 grams of proteids, 1,734 grams of carbohydrates as sugars and pentosans, 1,211 grams as cellulose, and 1,817 of extractive matter, not more specifically classified, and from this the animal appropriated 19,424,180 heat units and showed a gain of three and one-half pounds of flesh. On the other hand, we find that the lot fed on the saltbush digested 7,351 grams of dry matter containing 1,090 grams of proteids, 1,280 grams of carbohydrates as sugars and pentosans, 2,064 grams of cellulose, and 2,917 grams of extractives which we have not endeavored to more nearly classify, and from this the animals appropriated 23,149,533 calories, losing at the same time eight and one-half pounds. It is just that I should repeat that, while each of the three sheep lost, one of them lost but one-half pound, but the aggregate for the lot was 8½ pounds.

§232. The heat values of the various extracts of the alfalfa, corn fodder and saltbush were determined, and we found that, as a source of energy, the portion that I have designated cellulose is one of the most important.

§233. I have designated it cellulose to distinguish it from crude fibre, because the portion usually designated as crude fibre was treated in a moist condition with chlorin and then washed and boiled with one per cent. sodic hydrate and subsequently with sulfurous acid. This treatment with chlorin, etc., removed a considerable portion of the energy, but this energy is of little value in any of the fodders, the greatest value being observed in the case of the alfalfa, in which 24.0 per cent. of this energy was appropriated, but in the saltbush and corn fodder it was of no value. The total amount of energy removed from the crude fibre of the saltbush by this treatment was 8,508,528 calories out of a total of 59,205,051 for the hay, and from that of the alfalfa 6,045,840 calories out of a total of 49,585,495 calories fed. The relative quantity of heat removed from the crude fibre of the corn fodder by the chlorin is much less, *i. e.*, 1,482,734 calories out of a total of a little over 25 millions consumed and was wholly non-available. The alcoholic extract is again shown to be the most important portion of the fodder. The heat appropriated from this portion of the alfalfa was 10.7 millions calories out of a total of 30.9 millions; from that of the corn fod-

der, 7 millions out of a total of 19.4 millions, and from that of the saltbush, 5.8 millions out of a total of 23.2 millions.

§234. The second portion in importance was not the same in the three fodders, it being the sodic hydrate extract in the alfalfa and saltbush and the cellulose in the corn fodder. In the alfalfa 8.2 millions calories and in the saltbush 5.5 millions calories were appropriated from the sodic hydrate extracts, but this extract of the corn fodder furnished only 2.1 millions calories. The third protein in importance in the alfalfa and saltbush was the cellulose, which furnished 5.95 millions and 4.4 millions calories, respectively, in these cases. The fourth one in order of value is, in the alfalfa and saltbush, the hydric chlorid extract, from which the sheep appropriated 3 millions and 4 millions calories, respectively. The extracts of the alfalfa have, in the order given, furnished the larger amounts of heat, both absolutely and relatively, but this is reversed in the hydric chlorid extract, that of the saltbush furnishing the larger quantity. The order of extracts of the corn fodder in regard to their heat value is a different one, the alcoholic extract standing first, the residue or cellulose standing second, the hydric chlorid extract standing third, and the sodic hydrate extract falling to the fourth place. In the alfalfa and saltbush, we have a large amount of proteids, but we have seen that these are very freely dissolved by the alcohol and are represented almost as largley by the alcoholic extract as by that of the sodic hydrate, as the following amounts digested in the two extracts will show:

Alfalfa ....Alcoholic extract, 486 grams;	sodic hydrate, 698 grams
Saltbush ....Alcoholic extract, 553 grams;	sodic hydrate, 378 grams
Corn Fodder .....Alcoholic extract, 141 grams;	sodic hydrate, 000 grams
Timothy Hay ....Alcoholic extract, 129 grams;	sodic hydrate, 131 grams
Native Hay ......Alcoholic extract, 117 grams;	sodic hydrate, 194 grams

from which I infer that it is not probable that the value of the sodic hydrate extract in the alfalfa and saltbush is dependent upon the proteid content of the hays, but due to other compounds. In passing this subject, it may be noted that the proteids soluble in alcohol have as high or higher coefficients of digestion than those soluble in the sodic hydrate. The proteids soluble in hydric chlorid are less in amount and have lower coefficients of digestion than those soluble in alcohol or sodic hydrate.

§235. There appear now good reasons why the native and timothy hays might have repaid us for making a comparative study of them, even though the timothy has already been studied in this sense, at least to some extent, and the native hay could give results of a general value only.

§236. The native hay and corn fodder are apparently much more similar than any other two of the six; they gave the same

feeding results and both effected it at a comparatively small cost of energy. This is particularly the case with the corn fodder, which produced a gain of 3½ pounds in the weight of the sheep receiving it on the minimum weight of dry matter digested and a minimum of energy, 4,940 grams of dry matter, 19.4 millions of calories, and a gain of 3½ pounds. Alfalfa produced a greater gain, but the sheep digested 7,734 grams of dry matter, appropriated 30.9 millions of calories and gained 9 pounds. The effect of poor fodders are best shown by comparison with these, as sorghum, for instance, the sheep digested 6,725 grams of dry matter, 25 millions calories, and lost 8½ pounds; as saltbush, they digested 7,351 grams of dry matter, 23.1 millions calories and lost 8½ pounds.

§237. The methoxyl group is present in all of these fodders, but it is not abundant and is digested to only a small extent, as indicated by our results, and whether it plays any part in determining the value of the fodder or not, is not apparent.

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The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

COLORADO FODDERS

A STUDY OF COMPARATIVE VALUES
BASED ON BULLETIN 124

—BY—

W. P. HEADDEN.

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The Agricultural Experiment Station.

FORT COLLINS, COLORADO

A STUDY OF RELATIVE VALUES OF COLORADO FODDERS

A Continuation of Studies in Bulletins 39 and 93.

By W. P. Headden.

§ 1. The scientific feeder and student of animal nutrition has, for the past forty-five or fifty years, been accustomed to divide fodders into certain big groups to which different names have been applied and now the veriest tyro can talk very glibly of proteids and carbohydrates, but, after all, the practical man, and even our scientific friends, do not adhere tenaciously to the data indicated by the results of the calculations based on the analytical data, but adopt the plainer and easier way of judging the value of a fodder by the effect it produces. A grass may have, according to the results obtained by the analyst, an admirable composition, but if animals will not eat it, its good composition goes for nothing, or if they eat it and constantly lose in weight, the excellent analytic results are of no value. Facts similar to these are met with, sometimes in this extreme form, sometimes in a milder form.

§ 2. Hays made from different plants vary in quality, i. e., in their fitness to be used as fodders and in their fattening qualities. These differences are very great even when no individual idiosyncrasies of the animals fed can be appealed to to explain away the facts. In a bulletin published by the Colorado Experiment Station we have made an attempt to explain the reasons for these differences. It appears from this work that the extract obtained by boiling the fodder repeatedly with 80 per cent alcohol, is the most important part of the fodder; it contains a large, if not the largest, part of the nitrogenous substances and very large quantities of other matters.

§ 3. It is pointed out that water alone will extract as much as 40 per cent of alfalfa hay, This hay is easily damaged by rain. The explanation offered is the ready solubility of so large a portion of the hay.

§ 4. The alcoholic extract is itself highly digestible. This is true, too, of the nitrogenous matters contained in it. It is further demonstrated that this alcoholic extract furnishes more energy to the animal than any other portion of the fodder. This is true in each of the six fodders whose composition is presented.

§ 5. It is shown that the fodders yield extracts to muriatic acid, also to a solution of caustic soda, which vary in value in the different fodders. In some fodders, the former extract, but in others the latter, has the greater value. In alfalfa, the portion removed by the caustic soda, but in the Colorado native hay that removed by the muriatic acid is the more valuable portion. To the most of us, however, the surprising feature is the high value possessed by what is designated as residue or cellulose, the portion left after treating the hay with alcohol, muriatic acid, caustic soda and chlorin. It would seem that there would be but little or nothing remaining of a hay after being treated with these chemicals in the succession given, still

it is shown that one-half or more of this residue is digested by sheep in the case of alfalfa hay, native hay and corn fodder, but less than one-half in the case of timothy hay and sorghum fodder, and even less than one-third in the case of one of our native saltbushes which was studied with the purpose of seeing whether it might be used as a fodder. This residue or cellulose is not only digested by the animals to a large extent, over one-half of it being digested in the fodders which gave good feeding results, but the energy which it yielded to the animal was large, in the corn fodder, the alcoholic extract alone furnished more energy.

§ 6. We have heard so much about proteids and their value that we have come to think of these substances as the most important portions of a fodder. This is largely because they are not as abundant as some other kinds of substance and may be present in a fodder in such small quantities that the feeder may have to purchase them in order to obtain results which he desires. This bulletin does not in any way lower the value to be placed on the nitrogenous portions of the fodder, but it shows that the value of a fodder depends largely upon the character of its other constituents. The writer shows that two lots of sheep, one receiving alfalfa hay, the other salt bush hay, were digesting very large and nearly the same amounts of porteids but very different amounts of other substances included under the general term of carbohydrates, particularly was this true of the cellulose which represents those carbohydrates which were capable of resisting the action of the several chemicals previously named. The sheep receiving alfalfa gained nine pounds in live weight during the five days elapsing between he two weighings, and those receiving saltbush hay lost eight and one-half pounds. Attention is called to this fact and in explanation, it is pointed out that the cause of loss in the latter case is not due to a lack of proteids, for the amount of this class of substances digested is nearly as large as in the former case. The question in regard to the relative value of the nitrogenous constituents of the fodders is suggested and while it is admitted that there may be a difference in this respect they are assumed to be equal, no data being at hand to justify any assertion to the contrary.

§ 7. The two lots of sheep digested approximately the same amounts of proteids and it is held that assuming them to have the same value in the two fodders, the explanation of gain in the one case and the loss in the other is not to be found in this part of the fodder and consequently we have to study the effects of the other constituents.

§ 8. The amount of the different extracts, their digestibility and their fuel values are taken as indicators of their respective values. It is acknowledged that a small amount of some therapeutically active substance might exert a very markedly disturbing action, but though this fact was known and looked for no indication is given that such effects were noticed. In fact, the statement is repeatedly made that the animals appeared comfortable and contented, that they chewed their cuds contentedly or equivalent expressions. This assumption re-

garding the relative value of the proteids in the two fodders, which, by the way, have high coefficients of digestion, 72.99 in the alfalfa, and 66.2 in the saltbush, and the probable absence of any deleterious substances having been made, there is left as the next important group, the substances represented by the nitrogen-free extract, which is divided into several parts, each of which, however, contains some proteids, except possibly the chlorin extract and the cellulose or residue.

§ 9. The alcoholic extract represents these nitrogen-free substances in a large measure, but contains at the same time a large portion of the nitrogenous matter of the plant; the extract obtained by exhausting the hays with cold water and hot water with subsequent addition of malt extract are, taken together, of some moment, as they represent in round numbers one-tenth of the air-dried hay and usually show from fair to good coefficients of digestion; it is also true that the portion removed by treating the portion remaining after boiling with one per cent caustic soda, with chlorin, again heating with caustic soda and subsequently with a solution of sulfurous acid, may amount to a noticeable quantity, but its coefficient of digestion is always low, often zero. So that the carbohydrates are practically divided into four parts, those soluble in alcohol, those soluble in muriatic acid, those soluble in caustic soda and those which are insoluble. The value of this class of substance has always been recognized but in this work it is emphasized, particularly in the comparison of these two fodders, the alfalfa hay and saltbush hay. In the former they are not only abundant in the alcoholic extract but they are also highly digestible; but this is not true of the other three important parts of the saltbush hay, i. e., the parts soluble in muriatic acid, caustic soda and that which is insoluble in any of the solvents used; these parts of alfalfa hay have high coefficients of digestion and the sheep gained in weight, but in the case of the saltbush hay they have low coefficients of digestion and the sheep lost in weight.

§ 10. The great difference between these two fodders, alfalfa, an excellent one, and saltbush, a very poor one, lies in the character of the carbohydrates present in the two plants. While the proteids may be different, they are abundant in both plants and are both highly digestible. In this respect these two fodders are much more nearly alike than any other two fodders studied. This is fortunate for in regard to the quantity of proteids present and their digestibility, the hays are similar but the carbohydrates in three of the important portions of the plants are very unlike, though abundant in both plants, They are very difficultly digestible in the saltbush and required so much energy to effect their digestion that there was not enough appropriated from the fodder to do the work and carry on the animal functions without using some of that already stored in the body, therefore the animals lost flesh.

§ 11. The large amount of proteids digested in each instance and their high coefficients of digestion are tacitly assumed to be presumptive evidence that they yielded more energy to the animals than

was necessary to do the work of fitting them for assimilation by the system. Their similarity in quantity and coefficients of digestibility is considered fortunate as practically eliminating the question of their influence, the difference of the effects of these food elements not being great enough to materially change the effects of the other elements in consideration.

§ 12. The carbohydrates are not divided into classes except to the extent and in the manner explained in the following: The familiar members of this class, glucose and cane sugar, do not occur in large quantities in ordinary hays, but they are wholly digestible and where present constitute a valuable factor in the fodder. The saltbush contains more of these two sugars taken together than the alfalfa does, so if we consider the value of the saltbush as depending on the quantity of these two substances alone it should be better than the alfalfa, but this is not the case. The same is true in regard to two others of these carbohydrates, the gums and starch which are more abundant in the saltbush than in the alfalfa. The frame work and tissues of the plants themselves very largely belong to this class of substances, carbohydrates, and though we do not know the definite composition of some of these plant constituents, they can be changed, in part at least, so as to yield compounds whose composition is known and the yield of such compounds by the different hays when treated with different agents has been made use of to establish the differences in the fodders themselves. The sugars already named are only two well-known members of this class of substances which include a number of others not so commonly known to the general public. Some of these related substances yield one and some another sugar under the action of certain agents. By taking advantage of these properties, the following differences between the alfalfa and the saltbush have been established.

§ 13. It should be kept in mind that the object had in view in doing this work, was not primarily to establish the value of the fodders but to find out, if possible, why one gives goods results and the other poor ones. There is a kind of sugar to which the name wood-sugar has been given because it is formed when wood is subjected to a certain treatment. The sugar or the material from which it can be made, is capable of being determined with approximate accuracy by methods which have been worked out. In this way, it is shown that certain carbohydrates are present in that portion of the alfalfa soluble in alcohol which are wholly absent from the saltbush and these substances in the alfalfa are easily digestible. A similar carbohydrate is present in the muriatic acid extract of the alfalfa. There is, however, twice as much of this substance in the corresponding extract of the saltbush, but that found in the alfalfa is wholly digestible, while that in the saltbush is wholly indigestible; this may simply mean that but little of this portion of the hay is changed while passing through the alimentary tract and fecal matter capable of yielding this substance is present in the dung in such large quantities that there is more in the feces than was taken

into the animal as food. But here is a big difference, one which appears to be too great to be explained away by unavoidable errors in the work. The individual extracts in the different fodders were examined in this way and also the residues or the cellulose that resulted from the treatment adopted. In this connection, it is shown, the carbohydrates yielding this substance taken as a common measure, that these residues or celluloses are very different in their values. The caustic soda does not, it is true, dissolve very much of this class of substances, but the alfalfa yields about one-third as much as the saltbush, of which but a small part was digested, while that dissolved out of the saltbush is not only nearly three times as great but a very much larger proportion of it serves as food. The most striking difference in the character of these carbohydrates is presented by the residues obtained which ought to be approximately pure cellulose and consequently have nearly the same value. This, however, is not at all the case, for this portion of the alfalfa has almost three times the value of that of the saltbush if the coefficient of digestion is a proper guide in judging of their value. A little later we will find that this fact is shown by another method, establishing with a considerable degree of certainty, that there is a very great difference in the character of this portion of the respective fodders.

§ 14. The muriatic acid extract of the alfalfa contains, as previously stated, less of the substance corresponding to the wood sugar than the saltbush, but the alfalfa yields a sugar that may also be obtained from milk sugar and which is not present in the saltbush, or if present at all, constitutes a very small portion of the fodder. This sugar is apparently very digestible. The coefficient obtained for all the sugar found in the muriatic acid extract which included both kinds of sugar mentioned is high. There is but little of the material corresponding to the wood sugar present in this portion of the alfalfa, but there is some. The alfalfa and the saltbush belong to entirely different orders of plants, and the pea family, to which the alfalfa belongs, yields this sugar which may be derived from the sugar of milk, while the saltbush and ordinary hays yield but little of this, yielding wood sugar in its stead.

§ 15. The energy relations, i. e., the amount of heat gotten out of the fodder by the animals and also out of the different parts or extracts of the fodders were determined and the fodders were found to be very different in this respect, as well as in those respects already pointed out. Furthermore, it was shown that the same amounts of energy appropriated from different fodders produce different results, measured by the loss or gain in the live weight of the animal, or we may say that the efficiency of the energy varies in different fodders.

§ 16. As we have, in the main, taken alfalfa and the saltbush for our purpose so far, we will continue to use them though we will have to take up the grasses later.

§ 17. We have previously related that it was found that the extract obtained by treating the fodders with alcohol appeared to be

the most important portion in all cases, though they showed a great difference in value in the cases of the different fodders. In these, the alfalfa and the saltbush, the amounts of alcoholic extract digested by the lots of sheep in five days chance to be the same, but the energy appropriated by the lot which received alfalfa was very much greater, nearly twice as great as that appropriated by the lot that received saltbush. It will be recalled that it was stated that there was so big a difference in the character of the carbohydrates of these two plants that it could not in any way be ascribed to errors of manipulation. We here find, by another method, that the alcoholic extract of the saltbush yielded only a little more than one-half of the energy that the corresponding alfalfa extract yielded. This difference might be due to the different quantities of proteids in the two extracts, but it is not, provided that they have even approximately the same value in the two fodders, for they received and digested a larger quantity of proteids in the form of saltbush hay than they did as alfalfa hay, showing that, viewed from the standpoint of fuel value, the difference very probably lies in the character of the carbohydrates. While it is admitted that little is known of the character of the proteids dissolved out of these or any other fodders by alcohol, we have as good a guide for our judgment in this case as we have in others pertaining to the character of fodders, i. e., the animals digested not only a larger quantity of nitrogenous matter when fed on saltbush but assimilated a larger proportion of that that they received. We will not consider all of the extracts in this manner lest too many similar statements should obscure rather than emphasize the facts intended to be brought out, so we will only consider the muriatic acid extract and the residue or cellulose. The former, muriatic acid extract, furnished very much more digestible dry matter in the case of the saltbush than in that of the alfalfa, one-third more, but its coefficient of digestibility was materially lower, two-thirds that of the alfalfa, and we find the energy almost exactly one-half of the amount yielded in the case of alfalfa. The proteids in this extract of these two fodders were nearly the same, both in regard to their quantity and digesibility, showing again that the difference was probably due to the character of the carbohydrates. The only other and last big feature of these two fodders that we will mention will be the cellulose which, owing to the method of preparation, contains very little nitrogen, no ready formed sugars or subsances soluble in alcohol, water, muriatic acid, caustic sodic or removable by chlorin, in other words, the soluble substances and those portions of the woody tissue capable of being broken up and removed by these agents had already been eliminated and though this residue would appear to be of but little value as food for the animal, we find it always one of the first three portions in importance. We would probably, without definite knoweldge to the contrary, not only consider this portion of but little value, but would expect to find it of nearly equal value in all cases, which is no nearer the truth than the former. In these two cases, we find that over one-half of the alfalfa cellulose is digestible while less than three-tenths of the saltbush

cellulose can be digested by sheep, and further, while the sheep received a much larger amount of energy in the form of saltbush cellulose than in that of the alfalfa cellulose, they were able to utilize only two-thirds as much energy, again showing that it is the character of the carbohydrates, peculiar, perhaps, to each individual tribe of plants which determines its feeding value.

§ 18. We have now rapidly examined these fodders in their main features, the most interesting of which is the relation of the energy values. There may be many errors in our work and serious mistakes of judgment, but all of these can not obscure the fact that a smaller amount of energy consumed as alfalfa produced a bigger result than a larger one consumed in the form of saltbush. In order to make this clearer to the casual reader, I will state this result a little more fully. The sheep consumed forty-nine million units of energy as alfalfa hay and gained nine pounds; the same sheep under as favorable conditions as could be produced, consumed fifty-nine million units of energy as Saltbush and lost eight and one-half, a total difference of seventeen and one-half pounds of flesh. The repeated observation that the carbohydrates of the saltbush, whether in the form of cellulose or the other forms making up the whole structure of the hay, are more difficulty digestible than those of the alfalfa may be interpreted as indicating that the work necessary to prepare the carbohydrates for assimilation is so great that it cannot be accomplished by the digestive processes in the sheep, when the saltbush is the only fodder fed, except by using up energy stored in the body in the form of flesh, muscle or fat. The amount of energy supplied was more than abundant to have produced excellent results, had the sheep been able to set it free without the expenditure of too much energy previously stored in the form of flesh. In the case given, there were actually ten million more units of energy in the fodder consumed as saltbush than in that consumed as alfalfa, but the energy which the sheep appropriated from the saltbush was, in round numbers, eight millions less than that appropriated from the alfalfa.

§ 19. The amount of energy appropriated by the sheep with which this experiment was conducted was a little over twenty-three millions units, a quantity somewhat in excess of the amount appropriated from two other fodders on which each lot of sheep made a gain of three and one-half pounds. This indicates that the absolute amount of energy appropriated in the case of the saltbush was considerably more than would have sufficed to maintain the animals in the condition in which they were at the beginnig of the experiment, but the fact is that they each lost. The question in regard to the cause of this loss is answered above in that we suggest that not only this energy was used up, but as much more as corresponds to eight and one-half pounds of flesh, in converting these carbohydrates into proper food for the animals, in warming the excessive amount of water which this fodder caused the sheep to drink, and in maintaining the animal functions.

§ 20. We have so far presented the study of the two fodders, alfalfa and saltbush, only incidental mention having been made of the

other fodders studied, one of which was studied as fully as the two already mentioned, namely corn fodder. This fodder is one easily digested in the sense in which we have indicated that the saltbush is difficulty digestible. By this I mean that comparatively small amounts of heat are used in the work of preparing this fodder for assimilation. In this case, we have a little less than nineteen and a half million units of energy appropriated and each sheep gained, the lot making an aggregate gain of three and a half pounds. This is the smallest amount of heat on which an actual gain was made. This shows the relative efficiency of the energy in the corn fodder, as compared with saltbush. This relative efficiency of the corn fodder would appear to be much greater if compared to that of sorghum in which form the animals appropriated twenty-five million units of energy and lost 8½ pounds. The fuel or energy values of the various extracts of sorghum were not determined but the coefficients of digestion, especially for the two large and important divisions represented by the muriatic acid extract and the residue, cellulose, indicate a low digestibility of the carbohydrates. The proteids probably do not influence these results in any material way. The results obtained with sorghum, it having been fed alone, were surprisingly unfavorable. The large amount of heat used and the low coefficients of digestion found for the greater portion of the fodder indicates that it, like the saltbush, requires more work to bring it to an assimilable form than is an equivalent to the energy yielded by the fodder. In the case of sorghum, the alcoholic extract is abundant and has a high coefficient of digestion, due, very probably, to the fact that it is rich in the two sugars, glucose and cane sugar. I did not determine the fuel values of this or any other of the extracts made of the sorghum. The fuel value of the fodder itself is almost exactly the same as that of the saltbush, which is low, thirty-eight hundred units of energy against forty-two hundred in the corn fodder, the actual difference being three hundred and fifty units for each gram of dry hay.

§ 21. The three important portions of corn fodder are, the portion dissolved by eighty per cent. alcohol, the cellulose and the portion soluble in muriatic acid. These extracts, the alcohol and muriatic acid extracts, both have very high fuel values and are easily digestible. The residue or cellulose has a rather low fuel value but owing to its coefficient of digestion being high, it furnishes more energy than any other portion of the fodder, the alcoholic extract excepted.

§ 22. The deportment of the proteids in this fodder is very different from those of alfalfa. The greater portion of them being found in the caustic soda extract in the latter case, while the greater portion is found in the alcohol extract of the corn fodder. The cellulose of the saltbush proved to be much less efficient in furnishing energy to the animal than that of alfalfa, but in comparing the efficiency of the cellulose of corn fodder and alfalfa we find that that of corn fodder is the more efficient. The animals did not eat the stalk with the pith cellulose if they could avoid it, so the cellulose in this case does not include much of the pith cellulose, though it does include some.

§ 23. The amount of proteids in the corn fodder is comparatively small and their coefficient of digestion low, so that, whatever their distribution and importance, their influence cannot materially alter the general results obtained. The corn fodder cellulose is instructive because it has a rather lower fuel value than the other celluloses, but it has the highest coefficient of digestion of any of them.

§ 24. We have now presented a hay made from a member of the pea family, one of the goosefoot family and one from a very coarse grass, corn. We will next consider a mixture of small grasses, our native hay, and pure timothy.

§ 25. The native hay is a mixture of grasses and sedges with some rushes. We find this hay quite similar in composition to the corn fodder but a smaller proportion of the digestible proteids is taken into solution by alcohol than in the corn fodder. The combined amount of glucose and cane sugar is less, the wood is greater and the amount of still another sugar to which I have not specifically referred, but which is found in the caustic soda solution, is large enough to be considered separately. Such are the striking features of similarity in the composition of the two. The fuel values of the native hay were not studied in detail but the general results were that twenty-two and a quarter million units of energy appropriated as native hay proved to be exactly equivalent to nineteen and a half million units appropriated as corn fodder, if the gain in live weight is a correct standard by which to measure their effects.

§ 26. The native hay contains more proteids than the corn fodder but not as large a quantity as alfalfa hay, and they have a high coefficient of digestion. The carbohydrates are easily digestible but less so than those of either the alfalfa or corn fodder, and we find that it takes some three million units more of energy in the form of native hay than in the form of corn fodder to produce the same result, which is in perfect keeping with the lower coefficient of digestibility of the carbohydrates of the native hay.

§ 27. The timothy hay was studied to the same extent and in the same manner as the native hay. We find in it the same characteristics that we found in the native hay; a moderate amount of proteids, but their coefficient of digestion is somewhat lower. The nitrogenous constituents are soluble in eighty per cent alcohol to the extent of about one-third of the total amount present and this portion has a high coefficient of digestion.

§ 28. It seems to be generally true that the nitrogenous matters soluble in alcohol are readily digestible, for instance, we find that of this portion of alfalfa, eight-tenths is digestible; of the timothy hay, eight-tenths; of the saltbush, nearly nine-tenths; of the native hay, six-tenths, and of the corn fodder, six-tenths. I have stated that the alcoholic extract of a hay stands before any other portion in feeding value, as indicated by its amount, general coefficient of digestion and fuel value. The statement seems to hold to a large extent in regard to the proteids. No distinction being made between the amids and the proteids.

§ 29. We find that the fuel value of the timothy hay is quite high, about forty-four hundred heat units for each gram of dry matter but the sheep can only utilize this energy to an extent of a little less than one-half, and as a result we find that timothy hay does not furnish enough energy to make a good fodder. The lot of sheep receiving the timothy appropriated nearly seventeen and a half million units of energy and showed a slight loss in flesh.

§ 30. I have in this work refrained from analyzing the extracts further and have permitted some indefiniteness in the statement of the results, but I consider these points of no material importance to our present purpose. For instance, I have made no effort to determine whether the wood sugar, xylose, is made up wholly of this sugar, or is mixed with another closely related one. I have also considered it a matter of small importance in this study whether the reducing power found in the caustic soda extract is really due to wood-sugar or to one more nearly related to cane sugar. The fact has been established that in some hays, at least, the wood sugar is a mixture of two sugars and that the sugar present in the caustic soda solution probably does not belong to the group of wood sugars at all. These questions pertaining to the nearer chemical composition of the hays are interesting and important but for the purpose of this bulletin, I have deemed them omissible. The difference in the sugars from the alfalfa and other fodders has been mentioned, but this sugar, galactose, appears to be present in some of the other fodders, too, to a smaller extent.

§ 31. We find the difference between these fodders so marked, especially, in regard to the readiness with which they appear to yield their energy to the animals and the work which is necessary to prepare the food constituents for assimilation, that it does not appear strange that the fodders acually have very different feeding values.

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CANTALOUPE BREEDING

BY

P. K. BLINN

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CANTALOUPE BREEDING

PHILO K. BLINN

The cantaloupe industry has made its principal development since the introduction of the Netted Gem variety; for due to its small uniform size and good carrying quality the growth of the industry has been possible.

It was not until the excellent quality of the cantaloupes produced on irrigated land under dry climatic conditions was realized, that the industry became prominent.

The first cantaloupes on the eastern markets from the arid region were shipped from Rocky Ford, Colorado, in 1896. Their superior flavor was an innovation to the eastern melon trade; the contrast in quality was so striking as compared to the eastern and southern products that the Rocky Fords at once became regarded as a new variety, and under that popular symbol have won a national reputation. Each year thousands of cars of cantaloupes are marketed as genuine Rocky Fords, but from widely distant fields; those from the southern states appearing on the markets early in May, and continuing the supply from various states until late in October.

The phenomenal growth of the industry and the great demand, has established the cantaloupe as one of the favorite fruits of the American table; if the quality could always be assured there is hardly a fruit that could rival it in popularity or price.

Some of the causes that lead to poor quality are: Unfavorable climatic conditions, plant diseases, insect injuries, glutted markets and the unavoidable delays in transportation; many of which are beyond any apparent means of control. Yet when we consider what has been accomplished by plant breeding in other lines, it does not seem impossible that there could be developed a disease-resistant cantaloupe that would possess such superior qualities as to enable it to endure adverse conditions and still reach the markets in better state and with higher flavor than any we now possess. To this end cantaloupe breeding becomes an important feature of the industry, for at best the crop is a hazardous one, due to the above named influences and until recently careful seed selection has been generally neglected.

A GOOD DEMAND FOR GOOD SEED.

The general growth of the industry has created a large demand for cantaloupe seed, and naturally Rocky Ford has been an important source of supply. It seems that it is more than the notoriety of the name that gives an intrinsic value to the seed produced

at this point, for the cantaloupe growers of California and the southern states look to Rocky Ford each year for their supply of seed. They unanimously concede that they can mature their melons a week to ten days earlier and be assured of more uniform results in regard to size and quality, when they plant the Colorado grown seed, than if they use the same strain after it has been grown native with them a year or so. It is a good instance of the change in plants, that environments may sometimes produce, and how these variations may be transmitted to a degree, when the plants are grown under other conditions. The effects of altitude and latitude have long been regarded as an influence that hastens maturity in plants when their seed are grown in lower or southern regions. It is also a notable fact that grains produced in the dry climatic conditions of Colorado are heavier per bushel and are superior in quality to that grown in humid sections where the rainfall is excessive; it is evident, that where the moisture is controlled, and the soil and weather conditions will develop the fine flavor and qualities found in the Rocky Ford cantaloupe, that the same conditions will, in a measure, lend an influence to mature the seed with superior germinating power, vigor of growth and strong inherent tendencies, over that produced in less favored localities. This would indicate that points in Colorado are destined to continue as superior cantaloupe seed growing centers, provided the growers will resort to the proper methods of seed breeding that will insure the improvement of the cantaloupe in all its possibilities.

INDEFINITE AND UNSYSTEMATIC SELECTION.

Those familiar with the subject realize that a large amount of the seed that has been saved in the past was not choice selected seed, for much of it is saved from cantaloupes that were unmarketable for some reason, or it was saved late in the season from immature melons after frost has destroyed the vines; improvement under such conditions would hardly be expected and deterioration would be almost inevitable. However, there are growers who have been interested in producing choice cantaloupe seed, but even at best their system of selection has been too indefinite and incomplete to insure the best results. The plan of most growers in selecting seed for their own planting, is to lay aside the choicest specimens from the piles as they are gathered for market; these may be further graded before they are finally saved for seed, which would seem that the system possessed some merit, yet it is quite analogous to the use of the fanning mill for developing improved grain, or the selection of seed corn from the crib to better the corn crop; the selection is incomplete, for the seed selected from an indiscriminate pile does not take into consideration the many inherent tendencies of the plant from which it was produced, no matter how

perfect the specimens may chance to be; another serious weakness is the lack of adherence to a definite outline of the qualities that should be embodied in a perfect cantaloupe.

The different ideals of selection have given rise to numerous strains of the Rocky Ford cantaloupes, which are simply the Netted Gem variety developed under different conceptions of type and quality; there may be the element of cross-fertilization in the origin of some of the strains yet the foundation stock of all was originally the same strain, and the general characteristics of this variety has constituted the principal lines that have been considered in the selection of the Rocky Ford seed. For example, the uniformity of size and the netting are points that have been considered and are well developed in several strains; yet equally essential are the inherent traits of the plant and the quality of the fruit. For example, early, prolific production and disease resistance are of prime consideration as well as a thick, fine flesh of rich flavor with no disagreeable consistency or after tastes which are all qualities that should be embodied in a perfect cantaloupe.

Doubtless the acme of perfection may never be realized, for some of the points may be antagonistic attributes, and the laws of plant breeding are not so well defined as to enable one to outline a scheme for seed selection that will insure the desired results in a given time.

AN EXPERIMENT TO IMPROVE CANTALOUPES.

The object of this article is with a view of outlining the methods and results of a definite investigation along this line, presenting the facts that have grown out of this work in such a way as to serve the future efforts in cantaloupe breeding.

The Colorado Experiment Station, in 1903, instituted an investigation to develop if possible, a cantaloupe that would be immune to the attacks of the fungus disease, commonly known as "melon rust" or "blight," which is a serious menace to the melon industry. The first effort was a study of the cantaloupe fields to ascertain if any resistant tendency existed in the various strains of the Rocky Ford cantaloupes.

Owing to the different soil and the cultural conditions of the different farms, it was impossible to draw conclusions, as all fields were affected to some extent and eventually all succumb to the disease.

It was evident that a comparative test under more uniform conditions would be necessary to determine the point in question. Accordingly the following season the principal strains of the Rocky Ford cantaloupes were tested in comparison on a piece of ground that had been seriously affected with the fungus. The plat was uniform in condition and had the same care in all respects, yet the

results of the test revealed that one of the strains had marked disease resistant qualities, for when the balance of the plat was practically dead and dried up with the disease the rows of this variety had a number of plants only slightly affected.

The seed of these resistant individuals were secured and the following season, 1905, the same plat of ground was again used, in order that the rust-resistant feature could be developed in as adverse conditions as possible. It chanced this season that one of the rows in the plat was planted with the seed of one cantaloupe and the product of this row was so uniform in all of its qualities that it was evident that individual selection was an essential point to consider; also the increased percent of the resistant plants gave evidence that the quality was transmitted and could be developed by seed selection.

The seed of the most resistant plants were again saved, but this time each one was kept separate, the next year, 1906, the same plat was again used. The test demonstrated that the product of some plants reproduced quite uniformly and in others there was a tendency to vary; this seemed to emphasize the importance of selecting individual melons as well as the plant, and isolating the breeding plats as far as possible to prevent undesirable crosses. One row in the plat was planted as a check row, with the seed of a very choice melon but which had not been selected for the disease-resistant quality. This row was destroyed with the rust at least two weeks before the balance of the plat gave signs of the disease to any extent. (Plate I)

As the disease began to develop in the plat, a careful study was made and the most resistant plants were numbered by a stake, and as the melons ripened the most desirable were selected and the seed saved separate with a descriptive record made of each. Near the close of the season the plat was gone over again and noted as to which plants had been the most resistant during the summer; this revealed the fact that a few had been more enduring than all the rest. The seed of these could be easily identified and those that scored the highest in points of quality, were selected for the work in 1907. The seed were planted in separate adjacent blocks of fifty hills each on the same old plat that now, for five consecutive years had been devoted to cantaloupes, which is enough to insure a failure on account of the disease with any of the ordinary strains of seed after it has been grown on the same soil so long; but since the beginning of the resistant selection the plat has shown a decrease in the presence of the disease, while in adjacent fields the fungus has been as prevalent as ever and even more destructive. Except for a few individual plants, the plat during the past season has been practically free from the disease.

PLATE I.

1. A VINE RUSTED ON CHECK ROW
2. ADJACENT VINE SHOWING RESISTANCE TO RUST

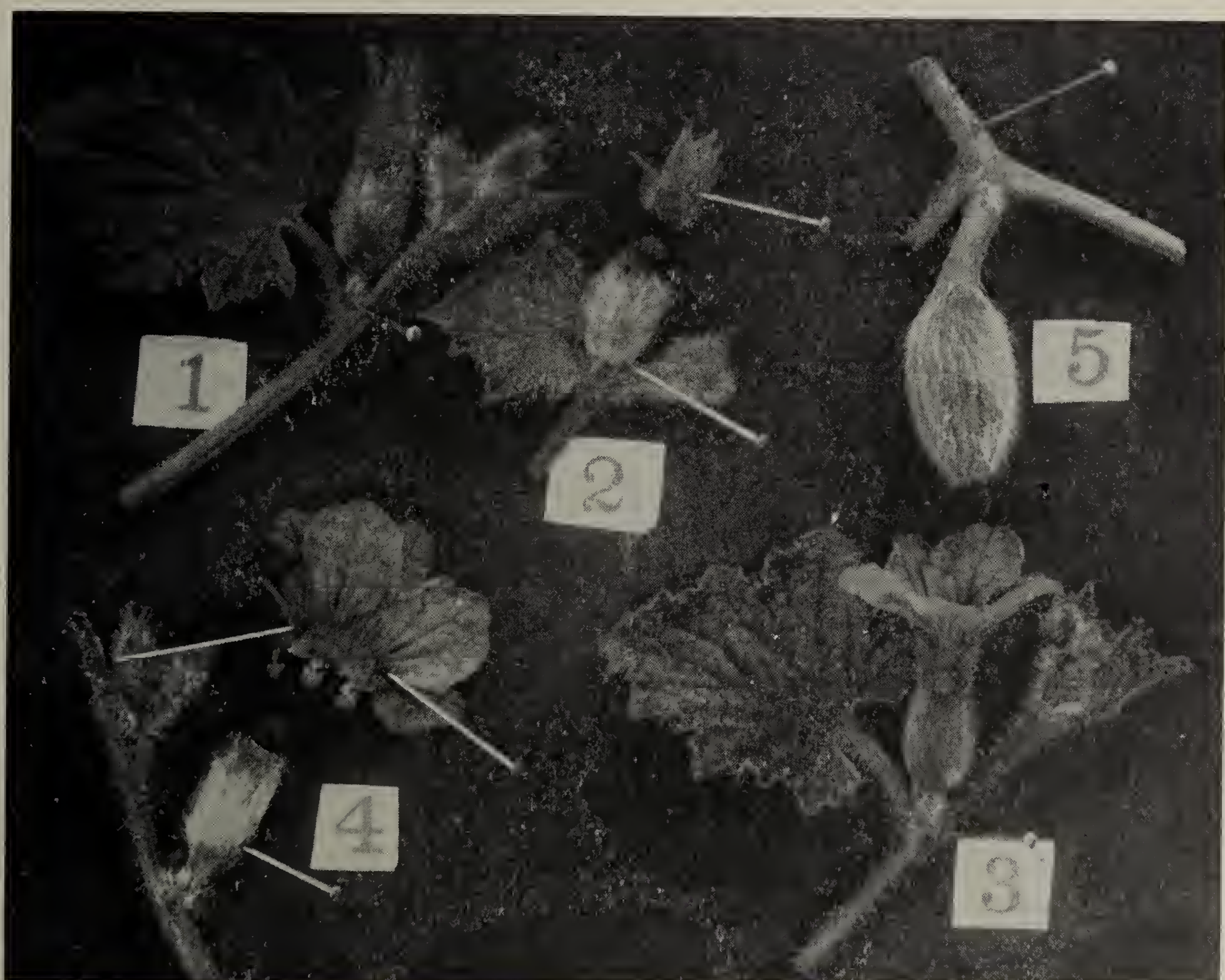


PLATE II.

1. BUD 24 HOURS BEFORE OPENING
2. BUD EMASCULATED
3. BLOOM JUST OPENED
4. CALYX AND COROLLA REMOVED, SHOWING 3 ANTHERS ATTACHED
5 SET DEVELOPING

PLATE III.

EXTERNAL POINT OF NETTING AND SIZE

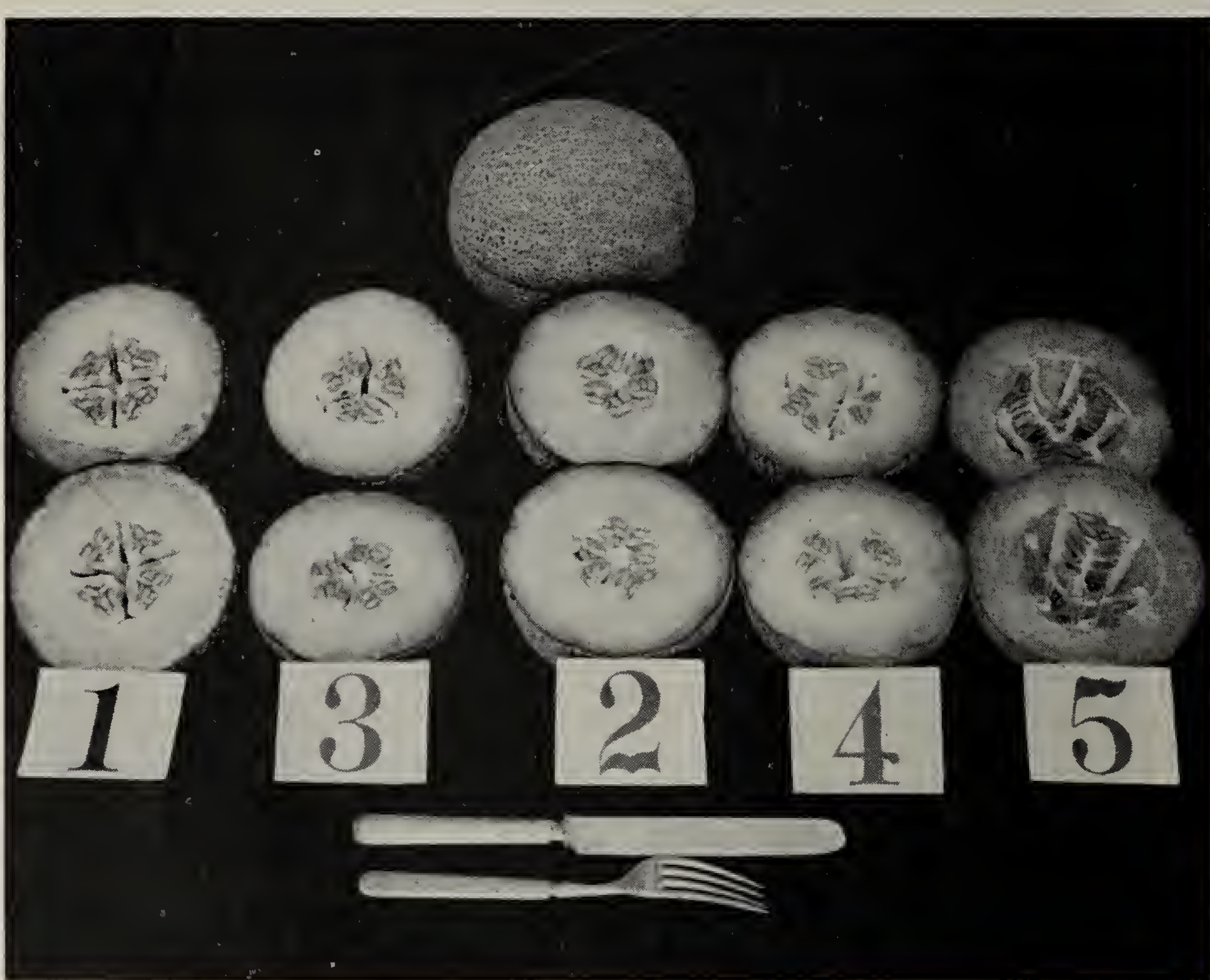


PLATE IV

CONTRASTS IN INTERNAL QUALITIES
NO. 2—PERFECT TYPE

PRACTICAL TESTS OF THE RESISTANT STRAIN.

Several tests of the rust-resistant strain were made with commercial growers in the vicinity of Rocky Ford, and all the reports have been of a flattering nature. Similar tests were also made in Illinois and Indiana through the co-operation of the Experiment Stations in those states, and the following copies of letters are the reports sent in.

From C. G. Woodbury, Assistant Horticulturist of the Agricultural Experiment Station, Purdue University, Lafayette, Indiana, under date of August 30, 1907:

"You remember that you forwarded me some seed early last spring, of your new strain of the rust-resistant Rocky Ford melon. I placed this out in several localities in Southern Indiana, where the rust is usually prevalent, and am very pleased to report that your strain has proven to be nearly immune; in one place where there was a small patch directly across the road from a field which the rust ruined entirely, the vines from your seed showed no effects of the disease whatever. To test the matter as severely as possible I had badly affected runners from the field that was dying of the rust cut off and scattered among the plants of the rust-resistant strain; even then they became affected only slightly.

"No doubt before this you have had a visit with Professor Orton of the Department of Agriculture, and he is able to corroborate my statements, since I had the pleasure of visiting some of the fields with him in Southern Indiana a short time ago."

From John W. Lloyd, of the University of Illinois Agricultural Experiment Station, Urbana, Ill., October 2, 1907:

"The melon seed you so kindly sent me last spring exceeded my highest expectations in reference to rust-resistance under Illinois conditions. I distributed the seed among a number of the commercial growers located at different points. Many growers lost or failed to plant the seed or did not secure a stand, but with all who succeeded in growing a crop the results were the same: The vines remained green and vigorous after other melons were dead from the rust; the melons netted exceedingly well and were fine flavored. The only objection raised against the melon was its late maturity; in some cases the entire crop from other varieties had been marketed before any ripe specimens of the rust-resistant could be found. It is true that the maturity of the other varieties was hastened by the rust.

"I believe this melon will be exceptionally valuable for extending the season after other varities are gone. However, in our experimental plat where the other varieties were protected by spraying and the rust-resistant plants left unsprayed, there was not so much difference in the time of ripening, though the rust-resistant were somewhat later. Toward the end of the season the **unsprayed** rust-resistant vines were in better condition than the sprayed vines of the other variety.

"The small lot of exceptionally select seed which you sent was planted by itself at a distance from other melons, and the plants thinned to one in a hill. There was considerable difference in the rust-resistance of different plants, and I have saved seed from some of the most resistant with a view of planting each separately, and making further selection next year."

The results of the investigation have demonstrated the possibility of controlling, to some extent at least, the injuries from the "rust" fungus by systematic seed selection and breeding.

VARIATIONS OF INDIVIDUAL SELECTIONS.

The seed of eighty choice individual cantaloupes of the rust-resistant strain were planted, on alfalfa sod, in blocks of twenty-five hills each, under as uniform conditions as possible. The object of this test was to determine the efficiency of the disease resistance on soil less affected with the fungus, and to study the problems of individual variation from individual selections, with a view of improving other characters in the Rocky Ford cantaloupe.

The test did not reveal any greater disease resistance by virtue of the alfalfa sod, but a marked contrast in the degree of resistance was revealed in the plats of different individual selections.

The variations of some of the plats made it easy to distinguish their outlines after the vines had run together and completely covered the ground in the field. The seed was all of the same variety and had been carefully selected for several years, and was considered a pure strain.

Had the seed been jumbled together and planted as usual, the contrast and variations of the different selections would not have appeared to attract attention, but by planting each separately it was evident that it makes a vast difference in results which one was chosen for seed, even from a number of seemingly choice specimens.

The first contrast noted was the variation in the germination of the plats, which ranged from forty to one hundred percent and was clearly the result of vitality in the selections, the date of first setting fruit varied eight to ten days in different plats without apparent reason, and the time of ripening of some of the plats was prolonged to nearly three weeks, though this difference may have been partly due to the premature ripening of some of the plats most affected with the fungus, and as the most rust resistant selections were usually the latest maturing plats, yet it was clear from the early setting and development of the plats before the disease was manifest, that some of the plats were much earlier than others. There were also various combinations of the different qualities in the different plats; for instance, the rust-resistant feature was associated with excellent melons in regard to netting, form and size, in some plats, while in others the qualities were inferior in this respect.

When the pedigrees were traced a general uniformity prevailed in the plats whose seed had a common parentage a year or two previous, yet irregularities were constantly appearing in the products of some of the selections, and also the tendency to breed true seemed equally characteristic of others. In one instance the color of the flesh and the solidly filled seed cavity was uniformly reproduced for four succeeding years.

The variations of the individual selections seemed to come from no other reason than the inherent tendency of the individual, for the whole plat had the same care in every respect possible.

The recent application of Mendel's laws of heredity offers an explanation of the results observed in this experiment. The heterozygous unit factors of some of the selections produced the irregular variations, while the homozygous, or pure unit factors of others, resulted in characters breeding true.

HYBRIDIZATION.

So far in the investigation we have employed only seed selection to secure the desired results; but now the need of hybridization is manifest to combine the desired qualities found in different selections, for simple seed selection has been inadequate to this object. To combine the rust-resistance with earlier maturity is much desired, and to this end observations and tests have been made during the past season to ascertain the fact and methods necessary for artificial cross-fertilization of the cantaloupe flowers. As a result several cross-pollenizations were made between some of the best selections of the rust-resistant strain and an abnormal early setting plant of another strain known as the "Watters." According to Mendels law of constant proportitions resulting from such hybrids, we may confidently expect the desired combination if the qualities are compatible.

It was found by observations that the flower of the Rocky Ford cantaloupe is quite the exception to most of the cucurbitaceous plants like the cucumber and many other varieties of melons, which have their stamens and pistils borne in separate flowers, while the Rocky Ford variety is hermaphroditic, that is the stamens and pistil are produced in one flower. It also has purely staminate flowers produced in great profusion at the intersection of nearly every branch.

It is evident that cross-fertilization is readily possible, yet the arrangement of the flower and the results of observation would indicate that self-pollenization is quite as common or more so.

The numerical arrangement of the flower was found to vary, the three-lobed pistil with three stamens was the common form, but four and even five were encountered. The result of a three-lobed pistil is shown in No. 1 in Plate IV.

METHODS OF ARTIFICIAL FERTILIZATION.

The pollen of the cantaloupe flower has been found to ripen about the time the flower is opened and the pollen is usually shed at this time, which is usually early in the morning; to fertilize the flower and have the results of known origin, it is necessary to find the bud about twenty-four hours before it opens (Plate II,

No. I), which can easily be told by observation; in this stage it should be emasculated, before the pollen lobes are ripe. By cutting around the base of the corolla and calyx, the two may be removed with the stamens attached, leaving the pistil free and exposed. (Plate II, No. II and IV.) A small paper sack is then tied over the stem to protect the pistil from foriegn pollen until the following morning, when the stigma will be at about the same stage, as if the flower had not been disturbed, and ready to receive the pollen.

The desired pollen is introduced from a fresh opened flower, by pulling off the corolla the stamens are exposed, showing the ripe pollen grains which are transfered by touching the ripe pollen lobes to the pistil or stigma until it is well covered with the yellow pollen grains. The paper sack is then replaced for several days until development begins.

SUMMARY.

The general conclusion of the investigation is that systematic seed breeding will intensify any desired qualities found in cantaloupes, as well as in corn and other crops.

The essential points for breeding cantaloupes are:

1. Keeping records that will establish the history of a plant at any time.
2. Close observation to detect desirable variations.
3. Individual selections.
4. Comparative testing to determine relative merits.
5. Judging the average results of a selection rather than the behavior of an individual in it.
6. An understanding of physiological botany, in order to perform successfully cross-pollenization when necessary.

The principal points, or unit characters to consider, might be enumerated as follows:

1. Germinating vitality. 2. Vigor of growth. 3. Early setting. 4. Quick maturity. 5. Prolific yields. 6. Uniformity of the desired qualities in the product.

The standard for the Rocky Ford Cantaloupe of today might be given to include the following qualities:

1. Proper size to pack in the standard crate.
2. Fine, heavy, light grey netting, covering the entire melon. Plate 3.
3. Color character of the background or interstices between the netting, such as will indicate to the eye, by a slight change of tint, when the cantaloupe is ready to pick, which is rather an olive green, and one that does not turn yellow fast.
4. A thick flesh and solid filled seed cavity. (Plate 4, No. 2.)
5. A firm, smooth texture, fine grained and free from any fiber or water-core.
6. A green colored flesh is usually preferred, though commonly it is combined with orange or salmon tint.
7. The flavor is the ultimate test; it should be rich, sweet and spicy, free from any disagreeable consistency or after tastes.

If the same care and attention was paid to the breeding and growing of improved cantaloupes, or other crops, there would be a great demand for pedigreed seed, as well as the call for registered horses, sheep or cattle.

Bulletin 127 January, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CLIMATE OF COLORADO

TEMPERATURE

21 Years' Record at Fort Collins

BY

L. G. CARPENTER

and

R. E. TRIMBLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

*After March, 1908

TEMPERATURE AT FORT COLLINS

21 YEARS' RECORD

Graphical Diagrams of the Normal Daily Temperature and the Highest and Lowest Daily Average

By L. G. CARPENTER *and* R. E. TRIMBLE

The Meteorological records for Fort Collins have been continued under essentially the same system for 20 years. Observations were made tri-daily up to July 1, 1889, when we changed to the twice daily records.

The average temperature which forms the basis of these charts is the mean of the maximum and minimum temperatures of the dav. The observations have been made by several different persons, but since 1891 have been made by Mr. R. E. Trimble.

The instrument house has been under substantially the same conditions, but moved several times for short distances. It has been of the Standard Weather Bureau type, a louvre-sided instrument house, with the floor about 6 feet above a grassy plot.

The dotted line of the diagrams shows the average temperature for every calendar day during the year. It is the average of 20 years, 1887-1906 inclusive.

The highest daily average during the 20 years is indicated by the upper line, and the lowest daily average by the lower line. Thus the warmest first of January in the 20 years averaged 39°, and the coldest -4°. The diagrams do not show the minimum temperature nor the maximum. The average range for January is 28°, and for August 33°. The range on the days of extreme temperature is much greater, often 40° or even 55°, so that if one selects the portion of day to be outside, the physiological effect is that of much more moderate extremes. This is still more the case when the extreme dryness of the climate is considered, moderating the physiological effect.

During the 20 years here recorded the maximum has been as follows.

MAXIMUM

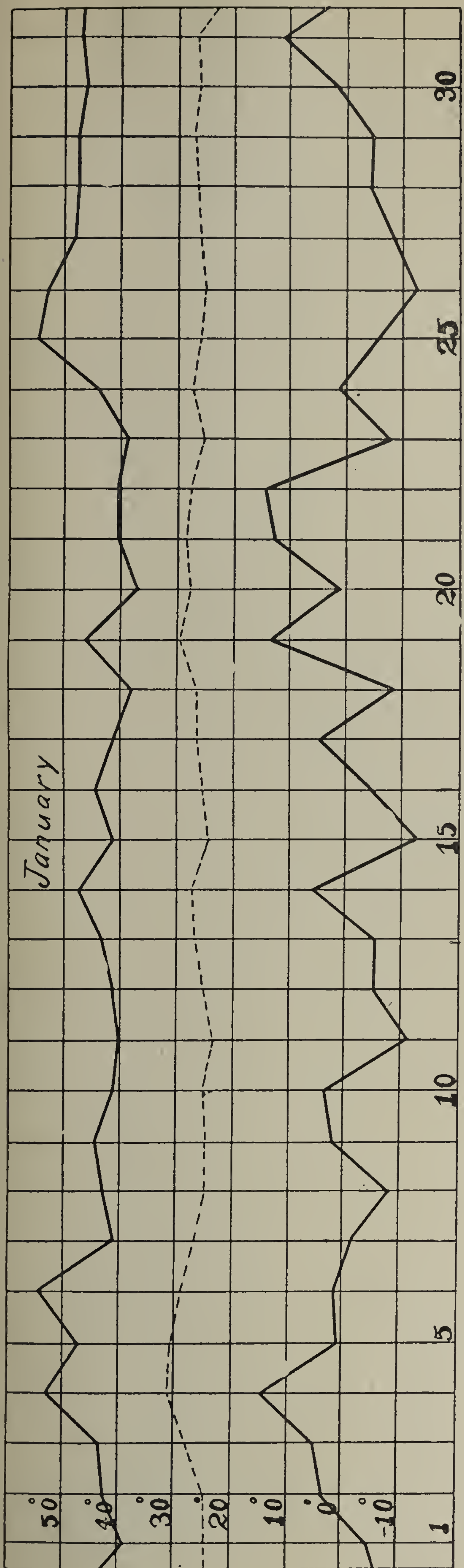
91°	1 year
93°	3 years
94°	3 years
95°	5 years
96°	2 years
97°	4 years
99°	2 years
99.6°	1 year

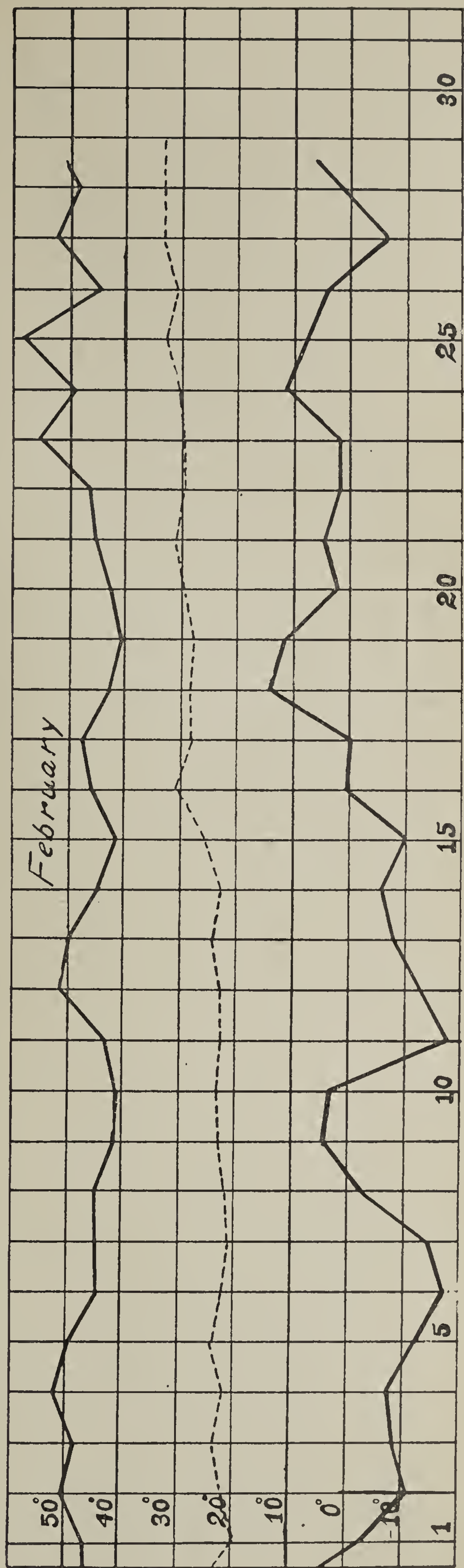
The minimum for the year has been as follows, below zero:

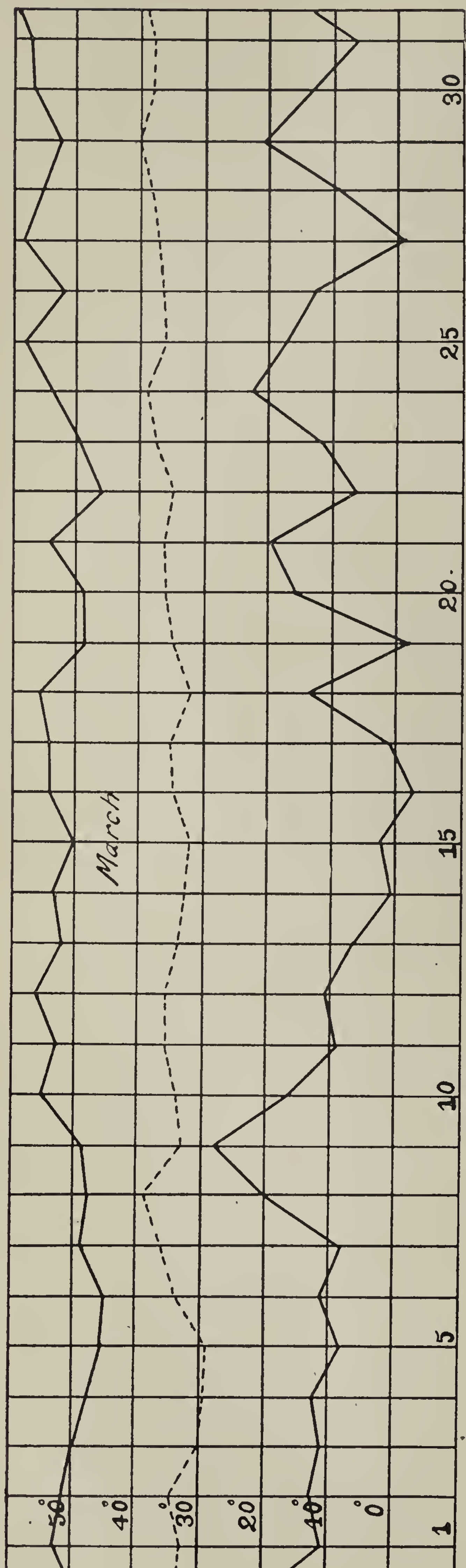
— 5°	1 year
6°—10°	2 years
11°—10°	2 years
16°—20°	4 years
21°—25°	4 years
26°—30°	6 years
31°—35°	2 years
—38.4°	1 year

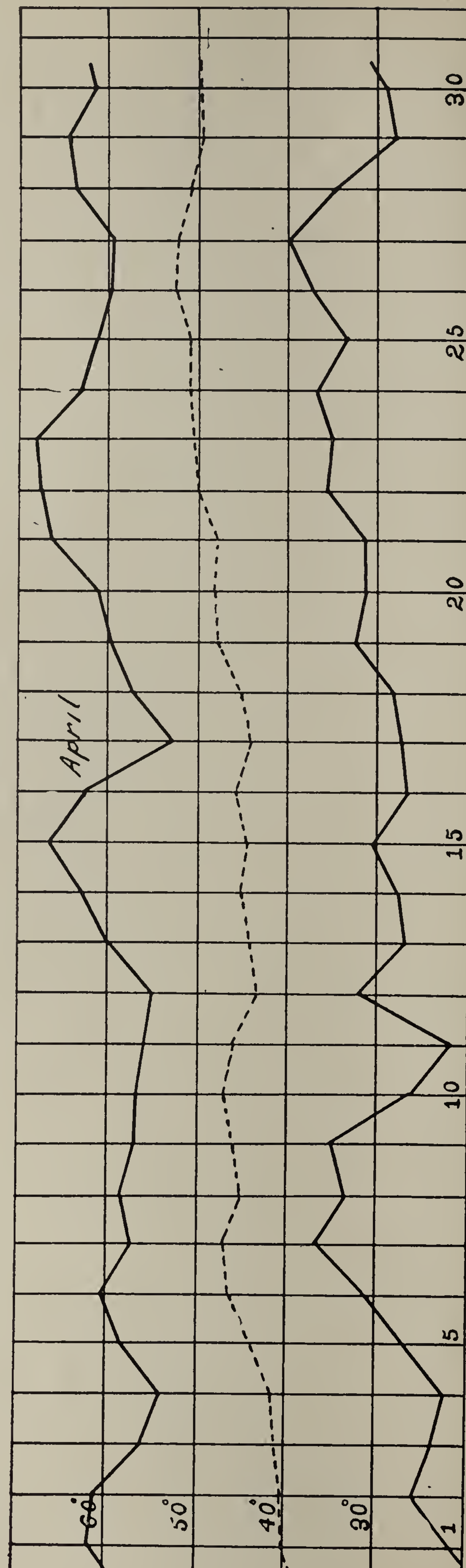
From the above record it is an even probability that the temperature will exceed or fall short of 94.6° for its maximum and -23° for its minimum. The average temperature is 45.7°, with a probable error of 0.2°; or it is an even probability from present information that after a much longer series of observations, the average will be found to be between 45.5° and 45.9.°

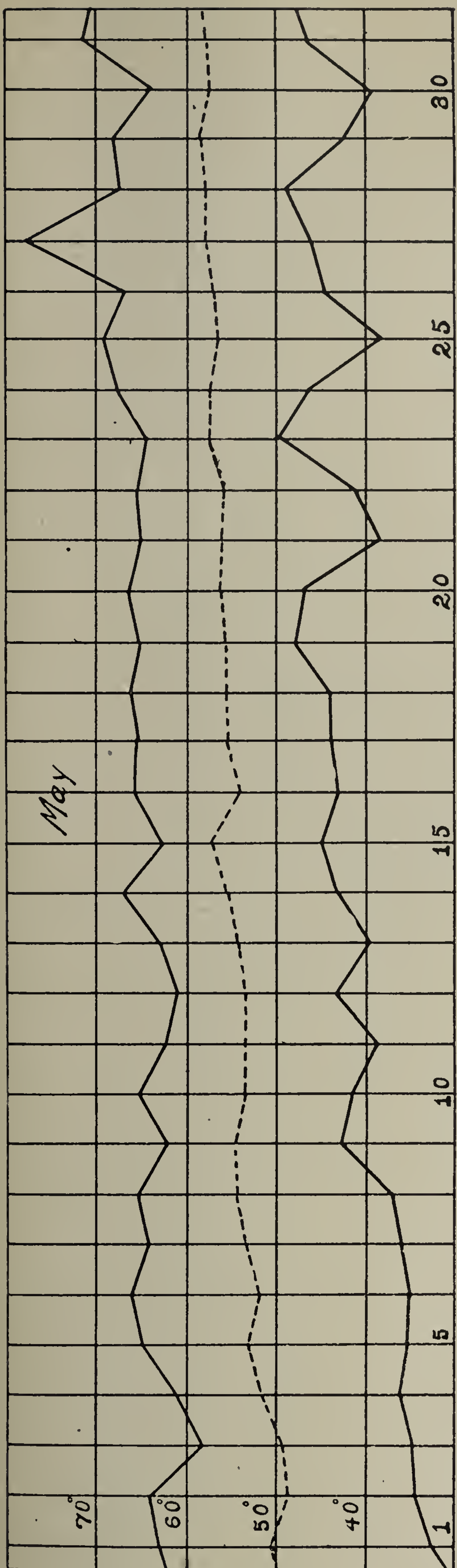
There is also given in Table I the monthly averages of temperature as found throughout the twenty years; in Table II, the table of extremes for each month; in Table III, the average daily range for each month.

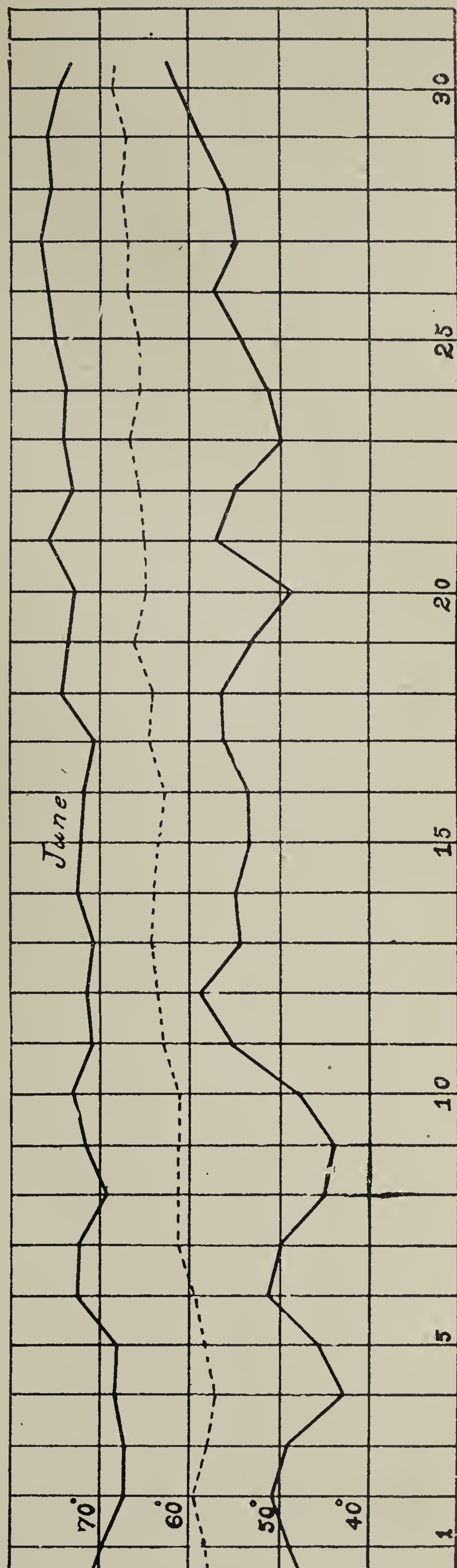

January
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

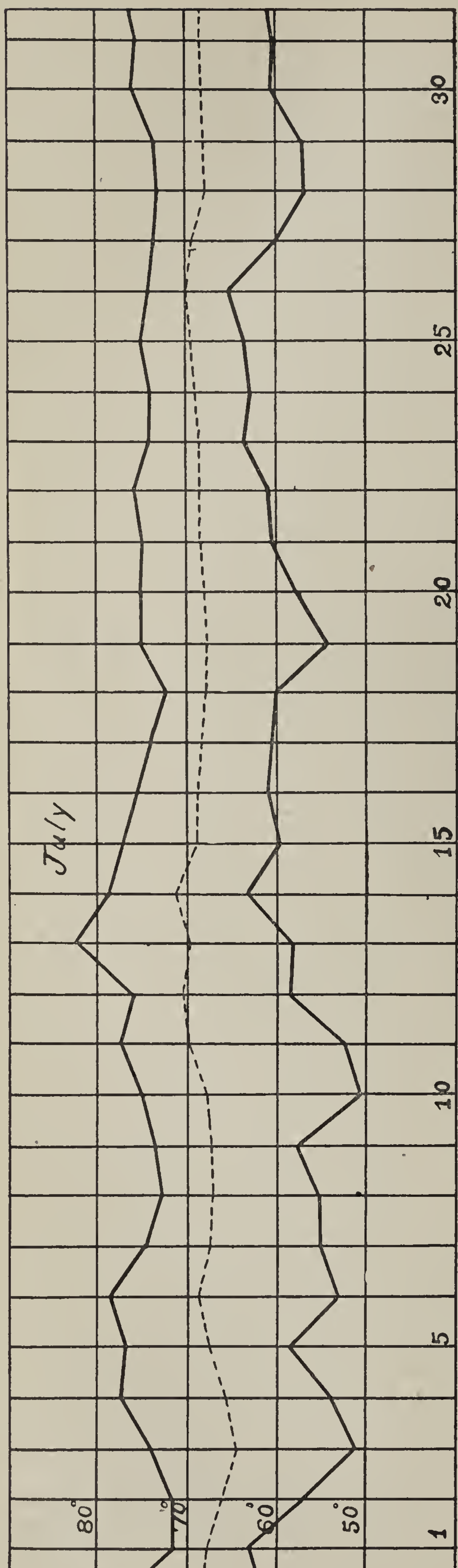

February
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

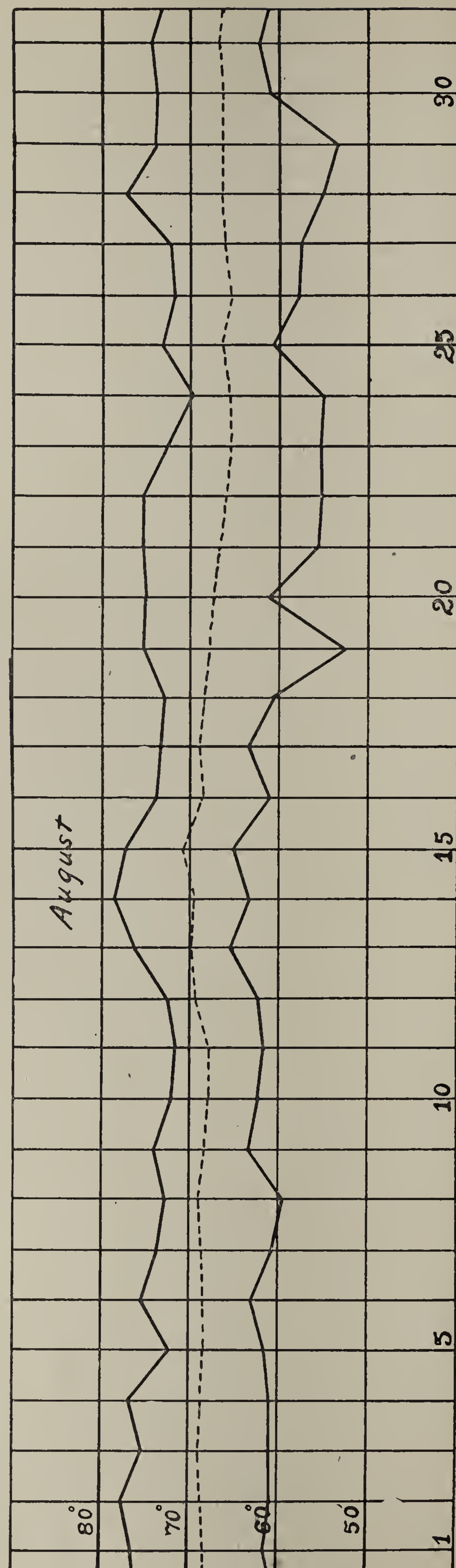

March
50°
40°
30°
20°
10°
0°
1
5
10
15
20
25
30

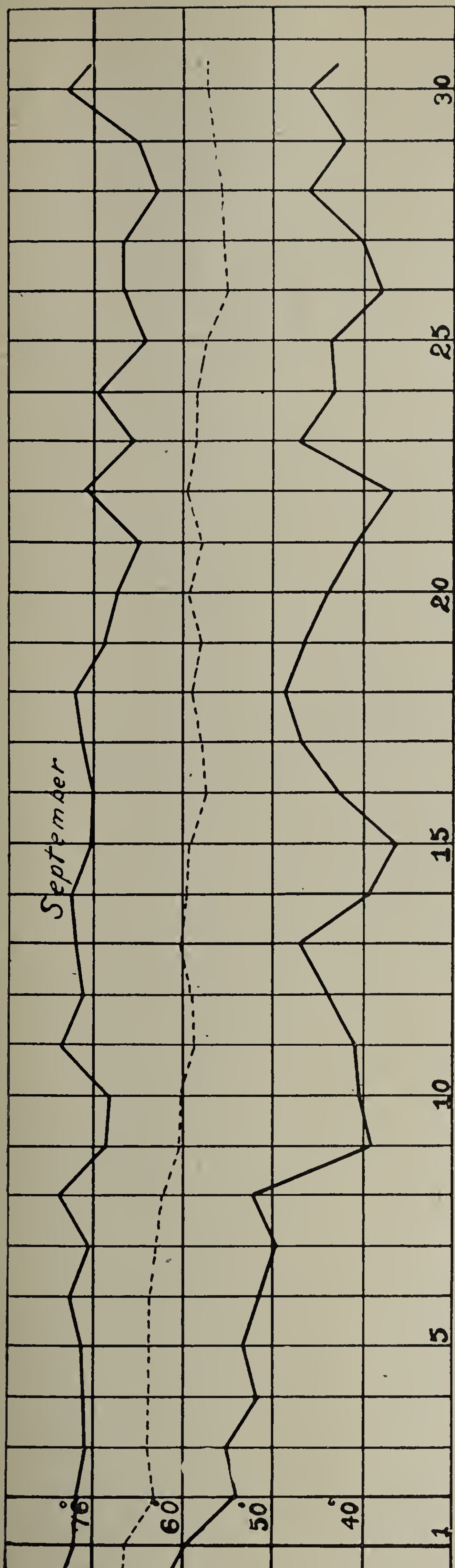

April
60°
50°
40°
30°
1
5
10
15
20
25
30

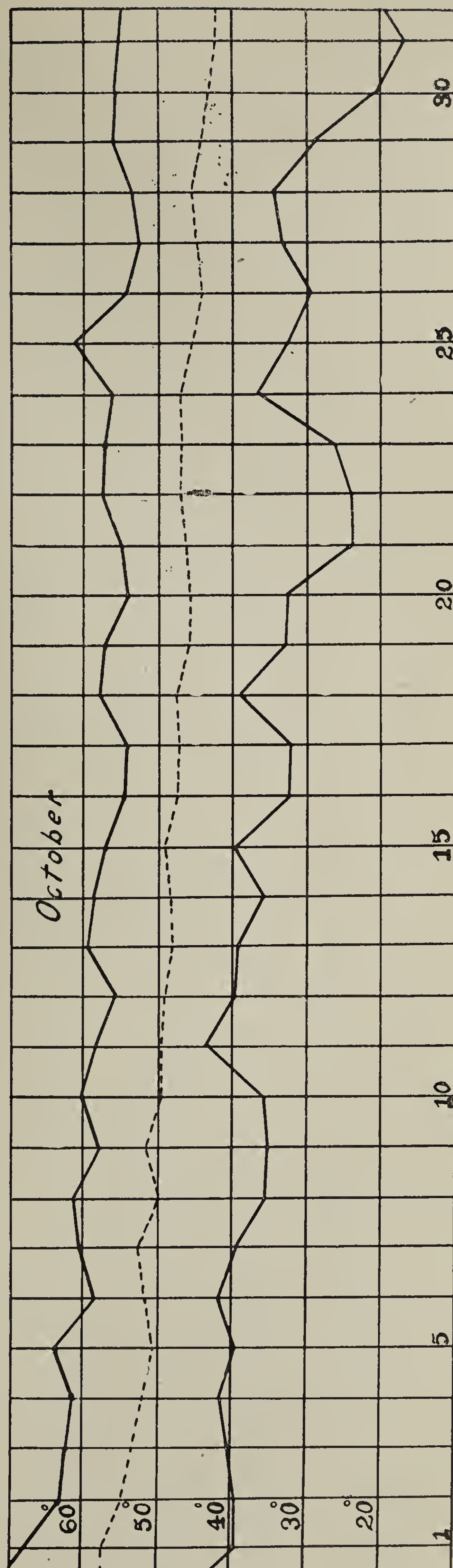

May
70°
60°
50°
40°
1
5
10
15
20
25
30

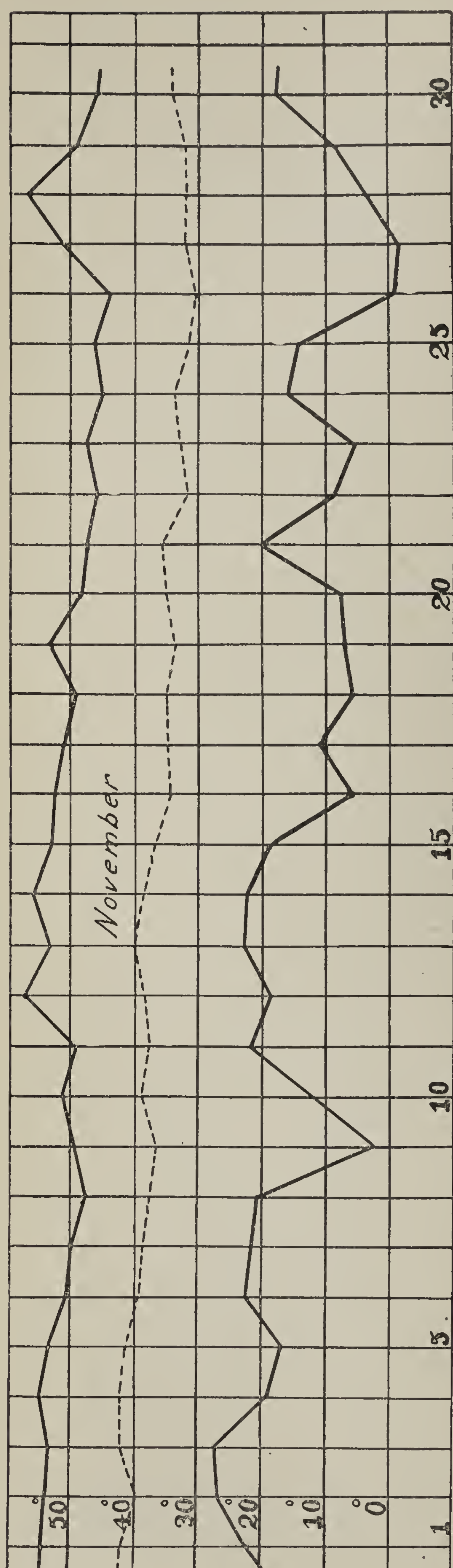

June
70°
60°
50°
40°
1
5
10
15
20
25
30


July
80°
70°
60°
50°
1
5
10
15
20
25
30


August
80°
70°
60°
50°
1
5
10
15
20
25
30


September
1
5
10
15
20
25
30
70°
60°
50°
40°


October
1
5
10
15
20
25
30
60°
50°
40°
30°
20°


November
50
40
30
20
10
0
1
5
10
15
20
25
30

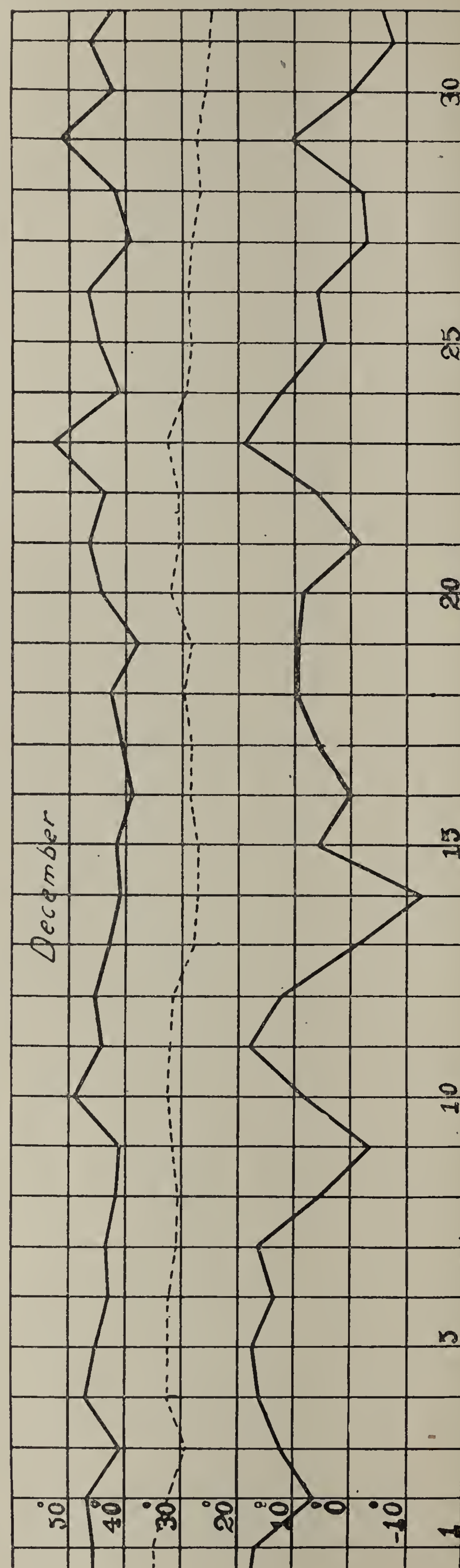

December
50
40
30
20
10
0
-10
1
5
10
15
20
25
30

TABLE I.
AVERAGE MONTHLY TEMPERATURE

At Agricultural College, Fort Collins, Colo., in Degrees Fahrenheit

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887........	25.7	23.7	39.8	45.2	57.7	68.1	68.4	65.6	60.4	46.0	38.2	29.7	47.1
1888........	22.2	37.1	37.4	55.3	54.4	68.1	72.8	66.6	61.4	49.2	33.0	31.3	49.0
1889........	22.2	25.6	41.6	50.6	54.1	63.5	68.1	66.6	53.9	44.1	27.0	32.1	45.8
1890........	24.7	30.0	38.0	46.5	58.0	64.0	71.1	66.1	58.3	47.4	38.1	37.8	49.1
1891........	22.2	19.8	30.5	46.6	54.8	60.9	66.9	66.3	61.1	48.7	35.1	28.7	45.1
1892........	21.1	27.8	33.7	44.0	50.0	61.7	68.2	67.3	62.4	47.7	37.4	23.1	45.4
1893.......	32.6	26.9	35.2	42.7	52.3	65.3	70.7	66.8	60.0	48.7	33.6	33.6	47.3
1894	23.9	18.7	37.4	48.3	57.2	63.2	69.1	68.3	58.9	51.3	40.5	25.6	46.9
1895.......	23.9	21.1	34.2	49.2	53.6	59.2	65.3	67.6	61.0	46.9	33.7	28.6	45.4
1896........	32.6	33.4	34.0	46.6	57.0	65.3	70.2	69.0	58.8	48.0	30.8	34.0	48.3
1897.......	24.8	27.6	32.3	45.8	51.8	63.1	66.8	66.8	63.7	48.5	35.6	25.4	46.6
1898........	25.6	34.1	32.7	47.7	51.6	64.0	69.0	69.9	58.6	46.3	30.3	23.6	46.1
1899.......	24.7	9.9	29.7	44.7	53.8	63.6	67.0	67.6	61.4	46.1	40.8	27.7	44.7
1900.......	30.9	24.2	39.1	42.9	57.8	67.1	67.9	68.0	58.6	50.2	37.4	31.6	48.0
1901	28.2	23.9	34.7	44.0	57.0	63.3	72.5	69.0	59.0	49.7	40.0	27.7	47.4
1902	24.2	32.0	35.3	45.7	56.1	63.6	66.0	68.7	56.8	48.8	36.1	27.1	46.7
1903........	30.3	14.0	30.6	45.3	52.2	59.3	68.5	68.1	56.8	49.6	36.1	32.3	45.3
1904........	26.1	35.3	39.6	46.2	53.7	59.9	65.6	67.0	59.2	48.9	39.7	31.9	47.8
1905	25.2	21.4	42.2	43.4	52.1	64.8	65.7	68.2	60.5	43.6	37.8	27.0	46.0
1906........	30.9	30.5	25.0	47.1	55.0	61.8	64.9	67.2	58.7	46.3	33.6	34.8	46.3
1907........	25.9	35.4	43.3	42.5	48.9	60.9	67.8	66.9	58.7	49.9	32.9	30.5	47.0
Average ...	26.1	26.3	35.5	46.2	54.7	63.4	68.2	67.5	59.4	47.9	35.6	29.7	46.7

*Fort Collins, Colo., Agricultural College. Latitude, 40° 34′. Elevation, 4,993 Feet. Located on the Plains, 4 miles east of the foothills of the Rocky Mountains.

TABLE II.
EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887......	58.	—19.0	70.	— 8.	80.	8.	83.	16.	90.	24.	96.	45.
1888......	71.	—28.	68.	14.	79.	3.	91.	30.	84.	30.	97.	42.
1889	58.	— 3.5	62.	—16.0	67.8	—17.0	79.	24.	81.	31.0	90.5	35.
1890	65.6	—13.0	68.3	—20.0	70.1	— 9.0	78.0	13.8	85.0	29.1	92.2	32.7
1891.....	48.9	—16.3	46.5	—1.50	66.0	— 4.1	81.9	12.9	84.6	31.2	86.9	37.9
1892......	61.2	— 28.4	55.1	— 9.0	70.1	—19.7	78.7	19.4	82.0	31.4	86.5	35.4
1893.....	67.3	— 2.2	66.7	—10.0	78.3	— 1.9	78.9	7.6	88.7	23.1	95.0	31.3
1894.....	63.3	—22.0	54.6	—15.3	73.0	9.9	79.0	16.4	85.9	27.1	91.0	37.9
1895.....	57.2	— 9.6	62.2	—27.8	80.2	—18.0	78.7	17.0	90.0	28.6	88.7	33.0
1896.....	67.8	— 7.6	68.1	3.9	75.8	— 6.8	80.0	7.0	88.3	31.0	91.2	39.3
1897......	64.0	—26.0	59.5	— 5.3	65.3	— 7.0	77.2	20.0	82.3	31.6	90.1	35.3
1898	61.5	—11.8	63.7	6.7	66.3	— 6.2	86.2	14.5	81.8	29.6	97.2	36.0
1899......	55.0	—16.8	50.8	—38.4	65.7	—24.5	78.0	8.0	82.5	23.4	96.1	36.4
1900	63.0	— 6.0	56.0	—23.4	76.9	9.7	73.9	5.1	84.7	29.8	94.4	40.7
1901	61.8	—21.7	63.0	—14.7	71.9	— 7.5	81.8	8.7	82.9	31.1	94.4	38.2
1902	62.2	—31.4	63.0	—23.0	63.9	2.0	79.8	18.0	85.9	29.6	96.0	37.0
1903	61.3	1.0	46.0	—28.0	66.2	—10.0	78.2	12.8	85.1	27.4	92.5	37.0
1904	65.0	— 7.0	69.0	3.0	70.0	10.0	79.8	14.1	82.0	28.2	87.2	38.4
1905......	63.5	—22.3	66.2	—26.8	70.3	12.4	78.0	12.0	76.3	29.5	92.3	40.0
1906	67.8	— 3.5	67.0	— 5.0	69.9	—24.6	80.1	22.1	82.9	33.0	89.9	37.2
1907......	62.6	— 4.7	68.8	— 2.8	80.3	2.8	80.0	5.7	83.0	19.2	87.7	33.9
Extreme	71.	—31.4	70.0	—38.4	80.3	—24.6	91.	5.1	90.0	19.2	97.2	31.3

TABLE II. (CONT'D.)

EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887......	**97.**	50.	97.	44.	91.	32.	88.	11.	78.	—13.	61.	0.
1888......	**99.**	51.	88.	44.	89.	32.	75.	20.	64.	16.	68.	4.
1889......	**97.**	37.5	97.	41.3	93.	23.0	85.2	24.9	61.	1.0	66.5	3.0
1890......	93.4	46.9	**95.3**	39.5	85.3	28.0	77.0	15.7	75.7	6.5	62.9	5.8
1891......	89.4	41.2	**93.1**	36.7	88.8	34.3	79.8	19.5	75.9	— 6.2	60.0	—10.0
1892......	92.7	45.3	**99.2**	33.9	89.3	27.5	87.0	18.7	62.7	10.6	65.6	—17.4
1893......	94.9	44.2	91.7	38.3	90.0	25.7	82.0	11.8	70.7	**—12.8**	60.4	2.5
1894......	**94.4**	46.0	92.2	39.5	88.6	30.9	80.7	19.3	78.0	— 1.1	64.7	**—24.0**
1895......	93.2	44.9	93.7	42.3	**95.0**	23.2	79.7	14.8	73.7	— 2.9	66.7	— 5.0
1896......	**95.8**	48.8	93.8	40.2	90.0	31.8	84.2	21.0	74.7	**—11.3**	66.1	0.5
1897......	**94.8**	38.9	93.5	42.7	89.8	33.8	81.7	21.5	75.6	— 3.0	63.0	—10.8
1898......	97.0	44.3	95.6	43.1	90.2	29.7	85.7	16.2	71.3	—11.3	55.0	**—22.3**
1899	94.0	44.6	95.2	39.7	94.6	29.0	86.7	23.7	69.5	15.0	63.7	— 9.3
1900.....	92.9	40.2	94.0	41.2	88.2	29.7	83.0	12.5	74.0	8.7	62.9	—22.0
1901......	**96.7**	47.9	96.7	43.6	86.6	29.4	82.0	25.0	69.6	12.0	64.6	**—31.0**
1902......	98.0	38.8	**99.6**	42.3	89.8	22.0	80.0	25.5	69.2	3.8	58.2	—17.6
1903......	**95.0**	36.0	94.6	41.9	92.5	26.0	81.0	20.0	71.0	—10.0	61.0	5.0
1904......	90.7	40.3	**91.0**	33.0	90.0	29.6	80.1	17.8	75.4	0.5	65.7	1.0
1905......	91.0	42.3	**93.2**	44.8	90.5	30.8	85.3	— 8.0	74.0	3.4	62.2	— 4.0
1906......	**92.6**	41.0	92.0	39.2	86.9	37.3	83.2	19.4	70.2	— 9.3	64.5	7.0
1907.....	**94.4**	44.6	91.6	45.0	85.6	31.0	81.8	22.4	70.0	— 1.2	61.7	**— 5.4**
Extreme	99.	36.0	99.6	33.0	95.0	22.0	88.	— 8.0	78.0	—13.0	68.0	—31.0

NOTE.---Extreme temperatures of each year indicated by blackfaced type.

TABLE III.

AVERAGE ~~MONTHLY~~ DAILY RANGE OF TEMPERATURE

At Agricultural College, Fort Collins, Colo.

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887........	23.2	31.5	35.3	28.6	32.6	33.1	29.7	31.7	32.8	33.6	30.8	27.6	30.9
1888........	32.7	28.	31.3	32.7	24.5	28.6	32.6	29.8	35.9	28.0	23.9	31.1	29.9
1889.......	28.2	27.2	28.8	27.5	25.2	29.6	33.1	34.2	34.9	28.7	25.4	28.6	29.3
1890	30.2	30.0	29.7	26.9	30.2	34.4	31.9	29.7	37.4	32.7	33.6	31.3	31.5
1891........	26.4	24.1	21.5	29.5	27.5	26.9	30.1	32.7	33.8	36.8	26.8	25.2	28.4
1892........	28.0	22.8	23.7	29.2	22.2	30.4	30.6	37.7	40.6	32.3	29.0	27.5	29.5
1893........	33.6	29.2	30.1	28.7	29.0	36.1	34.6	32.6	37.4	34.0	32.2	27.2	32.1
1894........	31.0	30.0	29.9	32.5	28.8	32.2	32.6	33.4	34.8	34.3	34.5	29.5	32.0
1895........	26.1	28.2	28.7	34.1	29.4	28.7	27.8	32.5	38.2	34.1	29.4	29.3	30.6
1896	32.9	31.5	24.5	32.3	31.5	31.4	29.2	32.2	28.0	33.2	28.5	30.1	30.2
1897........	30.9	26.7	25.0	27.5	30.2	28.9	32.9	30.9	32.6	32.6	30.8	27.2	30.1
1898........	30.1	33.0	30.4	33.6	22.3	31.7	32.1	35.4	39.4	29.6	28.4	28.6	31.2
1899........	28.6	30.7	23.6	31.6	31.6	32.5	28.6	33.1	37.9	28.3	31.8	29.9	30.7
1900........	31.4	27.1	29.6	23.3	29.2	33.8	31.6	37.0	30.6	34.8	31.4	31.3	30.9
1901........	31.2	29.0	26.9	25.8	28.2	30.0	35.2	32.1	32.7	33.7	33.4	25.2	30.3
1902........	30.0	27.0	25.5	30.6	28.8	30.8	33.0	32.8	34.6	31.3	27.0	25.5	29.7
1903........	27.8	28.3	24.4	28.2	31.4	24.6	32.7	33.7	34.9	35.3	34.2	33.4	30.7
1904........	33.3	30.2	30.4	29.7	25.0	27.1	29.7	31.6	33.7	35.0	39.9	32.0	31.5
1905........	25.4	29.2	25.9	24.0	23.2	29.5	29.3	34.1	37.4	33.5	31.8	36.2	30.0
1906........	33.0	35.5	23.0	25.7	28.1	39.1	27.9	32.2	28.8	31.6	24.9	26.6	29.7
1907........	26.9	31.0	32.0	26.9	23.8	31.6	30.8	31.9	33.0	35.4	33.4	29.7	30.5
Average....	29.6	29.1	27.6	29.0	27.7	31.0	31.2	32.9	34.7	32.8	30.5	29.2	30.4

Bulletin 128 April 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

ALFALFA STUDIES

PROGRESS REPORT

BY

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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PLATE I.

No. 13. A-4, 7-12, yield of seed 5 grams. Desirable hay type.

No. 14. Plant A-5, 7-18, no seed. Leaves dropped by fungus.

No. 7. G-6. Arabian Plat just 4 months old from seed. In bloom.

ALFALFA STUDIES

PROGRESS REPORT

BY P. K. BLINN

Alfalfa forms the basis of our farm values throughout the western states; its unique adaptation to the semi-arid conditions makes it an invaluable asset to our agriculture. Owing to its power to survive a drought, or exist on scanty moisture, its deep growing root system enables it to reach a great but a deep-lying supply of soil fertility, that is beyond the reach of common plant roots, but which will in turn, become available to any crop if the proper crop rotation with alfalfa is established.

The power of alfalfa to restore worn out lands, and to build up soil that is deficient in humus and nitrogen, is apparent to the most casual observer, who will compare the crops grown on alfalfa sod, with those on ordinary soil, or even where barnyard manure has been heavily applied. Realizing these facts, it is evident that alfalfa must be grown more extensively in our crop rotations to maintain and restore the soil that is being depleted by the large crops of sugar beets and other products.

Many acres of alfalfa hay land are sacrificed each year, for the more remunerative returns from beets, cantaloupes or potatoes grown on alfalfa sod, and as a result alfalfa hay is becoming scarce, and the price is advancing to a point that will tend to dishearten the stock feeder. Also the high prices realized for hay has not encouraged saving the alfalfa crop for seed, consequently the price of good alfalfa seed is about equal to the cost when it was first introduced. In the estimation of some, the high price of land in the irrigated sections precludes the use of alfalfa as a profitable crop; especially on the small tracts and even on the larger farms, the proper proportion of alfalfa to other crops is seldom maintained and evidently the *real merit* of alfalfa is overlooked.

When expensive land is occupied with alfalfa for recuperation, which sooner or later will become necessary, it is apparent to all that it should be made to yield the highest returns possible, in hay, seed or fertility. To this end the alfalfa seed breeding work has been instituted. The idea was suggested in 1904, when investigating the insect injuries and other causes for the poor yields of alfalfa seed in the lower Arkansas valley in Colorado. It was then noted that there was a great contrast in the seed yields of different plants under apparently the same conditions, and also, that the type and quantity of hay from different individuals varied. Seed from some of the most promising plants were secured and sown the following

season in a comparative test, with common alfalfa and some Turkestan seed from Germany, furnished through Professor W. H. Olin. This test the first season revealed a better seed production in the plants grown from seed selected for heavy yielding traits, but the second season's growth revealed the superior hay producing qualities of the Turkestan plants, which also yielded as high as an ounce of seed from a single plant. The selections that season were principally from the Turkestan plants, descriptions of which were reported in Bulletin 121, Colorado Experiment Station. Through Mr. J. M. Westgate, of the Department of Agriculture, a large list of foreign and native strains of alfalfa seed from different states were secured for a wider base of comparison in the preliminary nursery work of selecting the best strain for the improvement of the qualities desired in alfalfa.

The new alfalfa nursery planted the past season comprises sixty-four different varieties or promising individual selections, each planted at the same time and given the same care and conditions, and could be considered under a fair comparative test. Each plat was designed to contain two hundred individual plants, twenty inches apart each way, and each plat separated by a path forty inches wide.

The plats are designated in the following manner, the first tier of plats on the north are lettered "A" and numbered from east to west, one to eight, the next tier to the south is lettered "B" and the plats in the tier are numbered the same as the first tier, and so on, the eight tiers are lettered to correspond to the first eight letters of the alphabet.

The individual plants in a plat are designated by two numbers, the first denotes the number of the row in the plat, which is numbered from north to south, the second number denotes the plant in the rows, which are also numbered, but from the east to the west.

The nursery was planted April 15, 1907, and thinned to single plants about the middle of July. The following is an epitome of the first season's observations:

Plat A-1—Individual selection No. 1, from Turkestan variety, 183 plants. Irregular in type, undesirable for hay or seed compared to others.

Plat A-2—Individual selection No. 2, from Turkestan variety, 163 plants. Irregular in type, rather subject to fungus diseases.

Plat A-3—Individual selection No. 6, from Turkestan variety, 146 plants. Irregular in type, but fair for hay, no seed formed.

Plat A-4*—Individual selection No. 17 (from single plant on railroad right-of-way, grown without irrigation). Very uniform in type, upright in growth, fine stems and leaves, good hay type and fair set of seed, 165 plants. Very continuous in bloom.

Plat A-5*—Individual selection No. 12, from Turkestan plants, 179 plants. Irregular type, coarse stems, very sprangly growth, leaves shed off badly, no seed.

*See Plates.

PLATE II.

No. 16. Argentine alfalfa. From Plat E-4, 6-14. Good hay and seed type. 12 grams of seed.

No. 17. Argentine alfalfa. From Plat E-2, 1-19. Good hay and seed type; 13 grams.

Contrast in size of bloom.

Plat A-4, after plants were cut.

PLATE III.

No. 1. Arabian alfalfa, Plat D-2, 9-12. No. 2. D-2, 2-9.

Contrast in individual plants same age.

No. 8. Plat E-6, 9-5. Arabian alfalfa. No. 3. Plat D-3, 2-5. Mexican alfalfa.

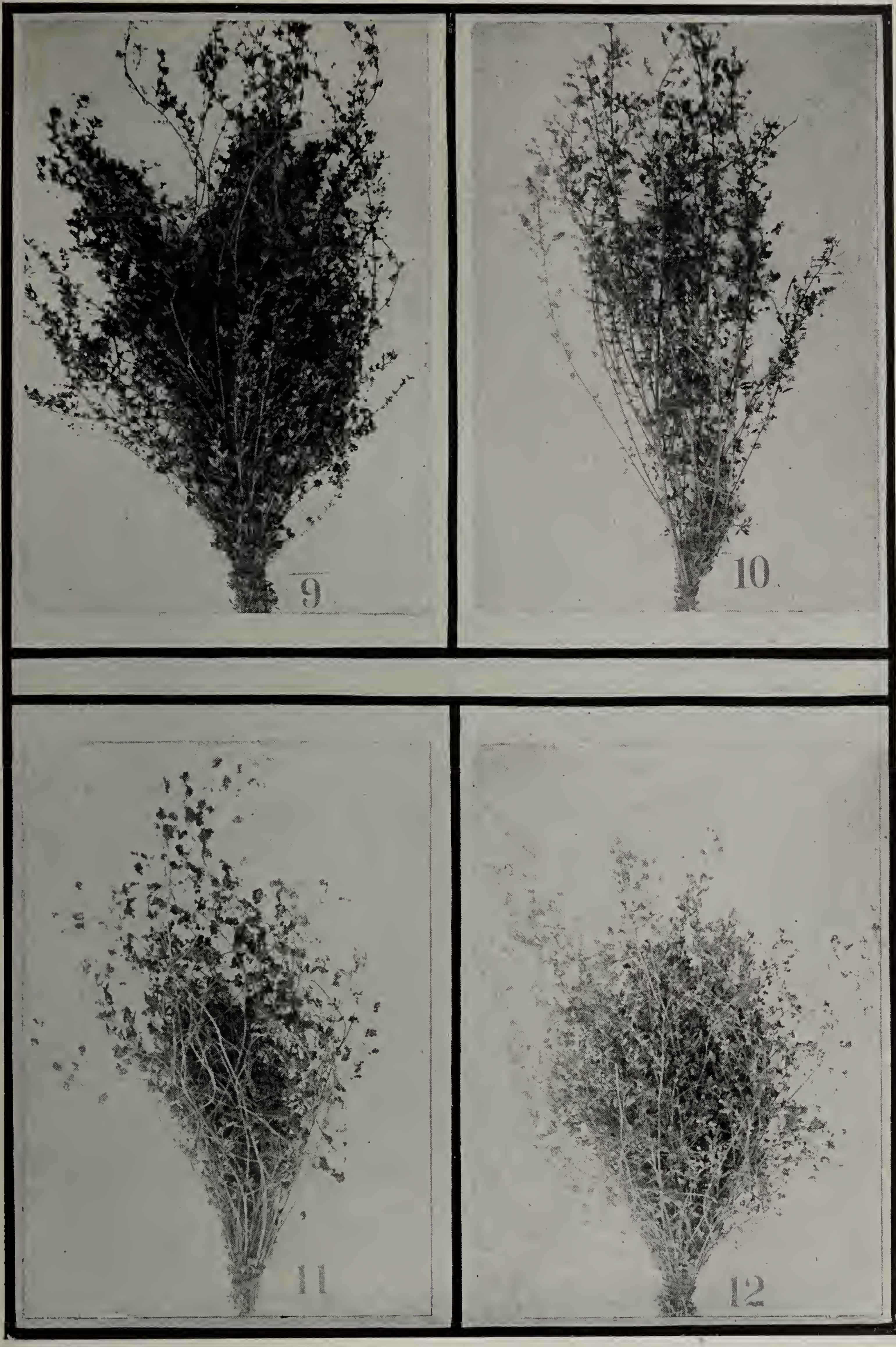

PLATE IV.

No. 9. Argentine. Plat E-4. Plant 7-6. Thickly set to leaves. Yield of seed, 2 grams.

No. 10. Ecuador. Plat E-8. Plant 7-1. Tall, stiff stems, set well to seed. Yield, 7 grams.

No. 11. Utah. Plat D-8. Plant 6-1. Remarkable yield of seed. 24 grams from 1 plant.

No. 12. Ecuador. Plat E-8. Plant 3-4. Fine combination of seed and hay quality. 15 grams.

PLATE V.

No. 15, from Plat E-3. Dry land Nebraska. Plant 10-17, to left. Remarkable stooling trait, 250 stems from one single plant the first year. Yield of seed, 7 grams.

No. 18, from Plat D-5, 6-20 Sand Lucerne, Pullman, Wash. Extra fine stems and leaves, fine hay type. Yield of seed, 4 grams.

Contrasting Qualities of Single Plants.

No. 5. From Plat E-4, 10-1. Argentine. This plant grew adjacent to No. 6, and shows that while they are similar in size there is a contrast in seed yield. Yield, 6 grams.

No. 6. From Plat E-4, 9-4. Argentine. This plant, while a fine hay type, is also a good seed yielder; produced 20 grams.

Plat A-6—Individual selection No. 16, from Turkestan variety, 153 plants. Irregular type, sprangly stems, but fair for hay, no seed.

Plat A-7—Individual selection No. 10, from Turkestan variety, 147 plants. Fairly regular in type, but leaves much affected with fungus, no seed, hay qualities fair.

Plat A-8—U. S. Department No. 991, Turkestan, 35 plants. Very poor.

Plat B-1—U. S. Department No. 12231, Texas Turkestan, 74 plants. Very irregular in type, but some good plants, no seed.

Plat B-2—Individual selection No. 3, Turkestan variety, 172 plants. Fairly uniform and hay qualities fair, no seed.

Plat B-3—Individual selection No. 7, Turkestan variety, 183 plants. Quite uniform, tall, coarse stems, no seed, good yield of hay.

Plat B-4—Individual selection No. 15, Turkestan variety, 180 plants. Fairly uniform in type, very dense set of leaves, very promising hay type, but no seed.

Plat B-5—Individual selection No. 9, Turkestan variety, 185 plants. Tall, coarse stems, no seed, hay fair.

Plat B-6—Individual selection No. 13, Turkestan variety, 181 plants. Fairly uniform type, hay good, no seed.

Plat B-7—Individual selection No. 11, Turkestan variety, 151 plants. Poor hay type, few leaved.

Plat B-8—U. S. Department No. 13999, Turkestan from Washington, 72 plants. Poor stand, but good hay type, but no seed.

Plat C-1—U. S. Department No. 12231, Turkestan from Texas, 29 plants. Poor plat.

Plat C-2—Individual selection No. 5, Turkestan, 166 plants. Fair type for hay, but no seed.

Plat C-3—Individual selection No. 8, Turkestan variety, 178 plants. Tall, stiff stems, coarse hay.

Plat C-4—Individual selection No. 14, Turkestan, 166 plants. Short stems, hay fair, no seed.

Plat C-5—U. S. No. 13521, Algeria, 66 plants. Hay fair, leaves free of fungus, no seed.

Plat C-6—U. S. No. 12803, Setif, Algeria, 123 plants. Hay fair, no seed, leaves free of fungus.

Plat C-7—U. S. No. 12846, Kebelli, Tripoli, 97 plants. Poor plat.

Plat C-8—U. S. No. 16401, Dryland, Pullman, Wash., 83 plants. Irregular in type, some good plants for hay and seed.

Plat D-1—U. S. No. 8823, Arabian, 61 plants. Regular type of upright stems, no seed, poor hay qualities.

Plat D-2*—U. S. No. 12992, Arabian, 129 plants. Very irregular, no good.

Plat D-3*—U. S. No. 11651, Pueblo, Mexico, 76 plants. Irregular type, but some good hay types, no seed.

Plat D-4—U. S. No. 14786, Turkestan, 143 plants. Tall, coarse stems, fair for hay, no seed.

Plat D-5*—U. S. No. 16399, Sand Lucerne, Pullman, Wash., 140 plants. Hay type good, seed fair.

Plat D-6—U. S. No. 17698, Northern Montana, 156 plants. Extra good hay type, thick set to leaves, free of fungus, no seed.

Plat D-7—U. S. No. 12847, Tebis, Tripoli, 60 plants. Much like Arabian alfalfa, upright stems, no seed.

Plat D-8*—U. S. No. 18827, Utah, 121 plants. Extra good type for both hay and seed in some plants, rather irregular on whole.

Plat E-1—U. S. No. 11652, Mexico, 98 plants. Irregular type, but some good plants for seed.

*See Plates.

Plat E-2*—U. S. No. 13768, Argentine, 143 plants. Extra good hay and seed type, leaves free from fungus.

Plat E-3*—U. S. No. 19566, Dryland, Nebraska ,169 plants. Good hay type, seed fair.

Plat E-4*—U. S. No. 12549, Argentine, 142 plants. Irregular types, but some extra good for hay and seed.

Plat E-5—U. S. No. 18470, Sand, Lucerne, Germany, 97 plants. Fair type for hay, no seed.

Plat E-6*—U. S. No. 16267, Irrigation Arabian, 106 plants. Regular in type, upright stems, large leaves, but sun scalded, no seed.

Plat E-7—U. S. No. 16317, China, 115 plants. Very sprangly, hay and seed poor.

Plat E-8*—U. S. No. 14972, Ecuador, 170 plants. Wonderful set of seed, hay fair.

Plat F-1—U. S. No. 11502, Siberia, 48 plants. Very poor traits.

Plat F-2—U. S. No. 13564, Peru, 138 plants. Short stems, fine, thick set with leaves, good seed and hay yield, seed not filled well.

Plat F-3—U. S. No. 9453, Turkestan Bokhara, 30 plants. Very poor types.

Plat F-4—U. S. No. 12772, Turkestan, Oregon, 111 plants. Irregular, hay and seed fair on some plants.

Plat F-5—U. S. No. 16403, Turkestan, Washington, 131 plants. Irregular, some good plants for hay and seed, stiff stems.

Plat F-6—U. S. No. 1159, Turkestan, Kuldja, China, 30 plants. Plants flat on the ground, no good.

Plat F-7—U. S. No. 19969, Highmore, South Dakota, 138 plants. Extra good hay and seed types in some plants.

Plat F-8—U. S. No. 19968, Turkestan, Kansas, 96 plants. Tall, coarse stems, no seed.

Plat G-1—U. S. No. 14497, Russia, 146 plants, Turkestan type. Hay and seed type fair.

Plat G-2—U. S. No. 13437, Arizona, 144 plants. Hay and seed qualities good.

Plat G-3—U. S. No. 18751, Turkestan, 154 plants. Coarse, stiff stems, few leaves, no seed.

Plat G-4—U. S. No. 9395, Turkestan, 75 plants. Sprangly, stiff stems, few leaves, no seed.

Plat G-5—U. S. No. 19508, Kansas, 132 plants. Well set with leaves, good hay type, seed fair.

Plat G-6*—U. S. No. 18628, non-irrigated Arabian, 142 plants. Upright stems, sun scalded tops, no seed.

Plat G-7—U. S. No. 13519, Spain, 142 plants, Arabian type. Hay fair, no seed.

Plat G-8—U. S. No. 13436, Canada, Ontario, 114 plants. Sprangly type, hay and seed only fair.

Plat H-1—U. S. No. 13440, Kansas, 132 plants. Thick set to leaves, good hay, seed set fair.

Plat H-2—U. S. No. 13487, Texas, 146 plants. Good hay type, seed on some plants.

Plat H-3—U. S. No. 679, Turkestan, Bokhara, 54 plants. Very poor type.

Plat H-4—U. S. No. 9452, Turkestan, 96 plants. Very tall stems, few leaves, no seed.

Plat H-5—U. S. No. 18591, Turkestan, Montana, 136 plants. Sprankly stems, hay and seed no good.

Plat H-6—U. S. No. 18425, Turkestan, 123 plants. Sprangly type, seed and hay no good.

*See Plates.

Plat H-7—U. S. No. 9450, Turkestan, Trans-Caucasia, 6 plants. Failure.

Plat H-8—U. S. No. 17792, Spain, 139 plants. Upright form like Arabian, hay and seed only fair.

In all our previous tests the Turkestan alfalfa has proven the most desirable in type for hay. It will be noticed from the above report of nursery that one-half of the plats were sown with Turkestan strains, yet the most leafy plants, and those producing the most seed, were not found in the Turkestan varieties. The second season's growth may reveal different records. Of the plats that produced seed, and were of promising type for seed and hay, the following selections were made, besides the individual selections of exceptional qualities:

Plat A-4—Seed from 150 plants, fine, leafy stems, quite uniform seed producing, secured 11 ounces of clean seed.

Plat E-8—From 50 plants, of heavy seed producing quality, secured 18 ounces clean seed.

Plat C-8—From ten choice plants secured 87 grams of clean seed, plants of short, jointed stems, thickly leaved and fairly set to seed.

Plat D-7—Seed of ten plants of the Arabian type, 71 grams.

Plat D-8—Seed of ten plants of the thick, fine leafed type, 70 grams.

Plat F-2—Seed of ten plants of the short, dwarfed stems, 118 grams.

The above six selections were made with a view of sowing increase plats in order to get seed in considerable amount, as these selections seemed so much superior to the common alfalfa. Besides this the following single plant selections were made, for their invidual merit.

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Extraction of Beeswax

BY

F. C. ALFORD

PUBLISHED BY THE EXPERIMENT STATION
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EXTRACTION OF BEESWAX

BY F. C. ALFORD

The increasing interest in apiculture in many sections of the State, and the frequent inquiries relative to the best method of extracting the wax, justify the preparation of this bulletin.

The combs used for the extraction of wax are usually old brood combs. These, of course, contain a large amount of foreign matter which renders the complete extraction of the wax very difficult, and results in forming a residue, known as slumgum.

Some of the methods in vogue at present have been practiced for a long time, others are of comparatively recent origin. Though I have sought for data, definitely established by experiments, regarding the relative efficiency of the different methods, I have been unable to find such, and have therefore attempted to establish the efficiency of some of the methods by experiments.

The classes of extractors experimented with include the solar extractors, those using steam, and those employing pressure under water at a temperature sufficiently high to melt the wax. We have experimented with the latter, using water alone, and also with the addition of sulphuric acid.

All experiments in extracting the wax were made with portions of one large lot of comb, and under comparable conditions. In those cases in which specific instructions were sent out by the manufacturers of the extractor, they were followed faithfully.

The study of this subject was extended to include the refining and bleaching of the wax, and also to include an indicator to find out something definite relative to the character and wax content of slumgum.

In all of this work we have been mindful of the suggestions and theories advanced by apiculturists during recent years, which was, of course, necessary in order to bring our work abreast with that of the Bee-keepers' Associations and individuals. I have profited by the suggestions of some of the prominent refiners of and dealers in beeswax who kindly answered my inquiries addressed to them, but in general I have found information regarding the extraction of beeswax very scarce, at least it is very difficult to obtain.

The General Properties of Beeswax. Beeswax, when obtained from clean, fresh comb, is a tough, compact solid, having a yellowish or brownish color, a fine granular structure and a very little luster. Its taste is faint and balsamic, but the odor is honey-like and characteristic. Beeswax does not feel greasy to the touch. It loses is color, bleaches, when exposed to the action of moisture and light, some varieties with

great difficulty. The presence of a small amount of fatty matter seems to facilitate the process. The melting point of beeswax varies with different samples, due to the fact that the proportion of its constituents may vary. The melting point is higher in old than in fresh wax, i. e., the melting point increases a little as the wax ages. Yellow wax melts between 61° and 63° C. (141.8° and 145.8° F.) Its specific gravity varies from 0.96 to 0.97 at 4° C.

The average composition of beeswax is, cerotic acid, soluble in alcohol, 14.4% ; myricin, insoluble in alcohol, 85.09%. There are, further, other compounds present, two hydrocarbons having been definitely recognized. The composition of genuine beeswax is approximately constant, and is not changed by natural bleaching, but chemical bleaching may increase the relative percentage of acid to 17 or 18%.

Comb Used. As the comb varied considerably, care was taken to get a fair sample for each experiment. The comb used was mostly old black comb which had been used as brood comb and was furnished by some of the beekeepers of the state and the Entomologist of the Station. The comb was sorted into three different grades; that designated as comb number one was white comb which had not been used for breeding pur poses. Number two comb was light brown, which had been used as a brood comb. It was darker than number one but not as dark as number three. Comb number three was a real dark comb and had been used for breeding purposes for a long time. Almost all of the experiments were conducted with combs numbers two and three, as almost all methods are very efficient with comb like number one.

Samples. Realizing that a little difference in the samples taken for the experiments would make a greater difference in the final result, we were very careful in the sampling of the material for the experiments. The comb was cut into pieces about an inch square and placed in a pile. The pile was stirred until well mixed, divided into quarters and the two opposite quarters placed in a pile. This pile was stirred and sampled as before. This process was continued until a sample of the proper weight was obtained.

SOLAR EXTRACTORS.

Two kinds of solar extractors were used, known as numbers one and two. Number one consisted of a wooden box thirty-two inches long, eighteen inches wide, and four inches deep. At the lower end a small box is placed to hold the pan which catches the wax. Twenty-four inches from the top there is a screen to hold back the comb. The upper portion of the box is lined with tin and the waste wax and brood comb are placed in this part of the box. The box is covered with a pane of glass held in a frame which fits the upper edge of the box. The heat from the sun melts the wax and it runs down, is strained by the screen, and is collected in a pan at the lower portion of the tin.

Number two extractor consists of a wooden box sixteen inches broad, seven inches deep and thirty inches long and has legs near one end so that it can be raised up at an angle toward the sun. The interior

is fitted with a concave tin lining to hold the pieces of comb, separated by a wire cloth straining screen from the wax pan, at the lower end of the box.

These two extractors were used because it was thought they represented, as nearly as possible, the average of the solar extractors used in this country. Some beekeepers have solar extractors which are much larger than either of these, but it is doubtful if they remove a greater percentage of the wax from the comb.

The experiments conducted with the solar extractors were made, as nearly as possible, under the same conditions. They were made on the same day and within a few feet of each other, on the south side of the Chemical Laboratory, so as to get the same outside temperature.

Number one held about twice as much comb as number two. On this account, it was necessary to fill number two extractor twice while number one was filled once. The first experiments were made to determine the comparative efficiency of these two solar extractors. For number one comb, extractor number two produced on the average about one per cent. more wax; for number two comb, about two per cent. more, and for number three comb, about one per cent. more than extractor number one.

The temperature of the extractor varied so much on different days that it was very hard to tell which extractor had the higher temperature. One day number two would have a higher temperature and the next day number one would. Taking an average of all the experiments where the temperatures were taken I find extractor number two exceeded extractor number one by about 0.4°C.

Solar Extractor with Lamp. It is the practice of some beekeepers to operate a lamp, stove or furnace in connection with the solar extractor. The extractors were inclined at an angle of about thirty degrees and an inclosure built back of them, to keep the wind from blowing the lamp. A lamp was placed inside the inclosure and a hole made in the bottom of the extractor so that the flame would strike against the tin lining of the extractors.

The addition of the lamp helped the extractor to heat up in the morning, to remain warm in the evening, and on a cloudy day, to keep the extractor warm when the sun was under a cloud.

By the use of the lamp the efficiency of the extractor was increased on an average about one per cent. The best results were obtained by having the heat from the lamp strike directly under the wire screen. Often on a cloudy day the wax will run down as far as the screen and then cool. By having the heat from the lamp warm the screen and the surrounding metal the wax is kept from cooling and runs down into the pan.

Double Glass. It was thought that the addition of an extra pane of glass might increase the yield. In order to try this an extra pane of glass was placed on extractor number one with one-half inch space between the panes. It was found that the use of the second pane increased the inside temperature on an average about 9.4° C. (17° F.) It was

observed that the extractor with the double glass was slower in becoming heated in the morning and held the heat longer in the evening. The efficiency of the extractor was increased, on an average, about seven per cent. for number two comb, and two per cent. for number three comb. Number one comb was not tested.

Double Glass and Lamp. As it was shown by experiments that the use of a lamp, and an extra pane of glass increased the efficiency it was thought that a combination of the two might increase it still more. This was tried and the results showed but a slight increase over either one alone and did not come up to expectations. The increase was about 0.7 per cent.

Bleaching. It was noticed that in rendering light colored wax by means of the solar extractor the wax was bleached. An attempt was made to determine the bleaching effect of the sunlight by exposing dark wax in the solar extractor for four days. The wax was exposed for that length of time because it was thought that it would not remain in the extractor longer than that during the ordinary process of extraction. Some dark wax which had been obtained from the Ferris steam extractor was placed in solar extractor number one and melted for a day. A sample of this wax was taken and the remainder remelted. This was continued for four days and samples were taken at the end of each day. At the end of the fourth day the samples were compared and it was impossible to note any change in the color of the wax.

Some dark wax which had been boiled with sulphuric acid was placed in solar extractor number two and melted. It was sampled and remelted the same as in the preceding experiment. It was impossible to notice any difference in the shade or color of the wax.

Slumgum. In order to see if the solar extractor could remove wax which the steam extractor was unable to remove, some slumgum from the Swiss extractor was put in solar extractor number two and heated for four days. The weather was very warm and at the end of the fourth day there was not a trace of wax to be seen in the extractor.

Honey. A number of experiments were made to see if the solar extractor could be used to remove honey from the comb. In the experiments conducted with the dark comb in warm weather, the honey obtained was dark and thick, had a scorched taste and could not be used for anything except feeding purposes. In the other experiments with light colored comb and with moderately bright sun the honey was light colored and of good quality.

Soaking Comb in Water. Some beekeepers make a practice of soaking the comb in water before putting it in the solar extractor, supposing that the soaking loosens the cocoons and dirt in the comb. Some number two comb was soaked in water for six days and put in solar extractor number one. Some comb which had not been soaked was used as a check, and the soaked comb showed an average increase of about one per cent. over the unsoaked.

Comb Soaked in Dilute Sulphuric Acid. It was thought that the soaking of the comb in dilute sulphuric acid might loosen the dirt and

cocoons and leave them in a free condition. Some number two comb was soaked for three days in a solution of five per cent. sulphuric acid, washed to remove the acid and treated in solar extractor number one for three days. Some comb which had not been soaked was used as a check, and the comb treated with acid gave on an average about five per cent. more wax than that not treated. Care had to be taken to wash all of the acid out of the comb before it was put in the extractor on account of the action of the acid on the metal linings of the extractor.

STEAM EXTRACTORS.

In determining the efficiency of the steam extractors three kinds were used, the Ferris, the Root-German, and the Swiss. The Ferris extractor was loaned to the department by Mr. M. A. Gill of Longmont, Colorado, and the Root was loaned by Mr. R. C. Aikin of Loveland, Colorado. The Swiss was obtained from the Station Entomologist.

The Root-German Extractor. This extractor was made by the A. I. Root Co., Medina, Ohio, and consisted of a small sheet iron tank or can with a false bottom. On an iron frame above the false bottom rests a wire basket. Pressure is applied by means of a screw which runs through the cover of the machine. Water is placed in the bottom and the machine placed on a stove. The steam, as it generates, rises through a hole in the middle of the false bottom, which is covered by a deflector. The comb, not too much, is placed in a burlap bag and the bag is placed in a metal basket which is put into the extractor. When the comb becomes thoroughly melted pressure is applied by means of the screw, increasing at intervals and not applied all at once. After most of the wax has been removed it is a good thing to remove the pressure, stir the slumgum and press again. With old comb it is best to stir and press at least two or three times. This extractor worked in a very satisfactory manner and the results show the efficiency of the Root extractor to be greater than that of any of the other steam or solar extractors.

The Ferris Steam Wax Extractor. This extractor was invented by Mr. C. C. Ferris of Richfield Springs, New York, and was the first extractor put on the market which used pressure in connection with steam as a means of extracting beeswax. The extractor consists of a galvanized iron tank in which are suspended two extra heavy galvanized wire-cloth baskets. Comb is placed in the baskets, water is put in the lower portion of the machine and the whole is placed on the stove. The steam as generated, passes upward into the baskets and melts the wax which runs down the inclined bottom and out the spout into a pan containing water. After part of the wax has melted pressure is applied in the basket by means of a screw and the wax is forced out of the comb while it is kept hot by steam. The comb is then stirred, heated and pressed again.

The Ferris extractor worked very well on number one comb, but it did not give good results with either comb numbers two or three. The machine was not made strong enough so that sufficient pressure could be applied to force all of the wax out of the comb. The screws for applying the pressure were too small and the method of fastening them not

very secure. The results show that on an average the efficiency of the Ferris extractor is about one per cent. below the Root extractor for number two comb and about twelve per cent. below for comb number three.

The Swiss Steam Wax Extractor. This extractor is made in two sections. The lower one is an ordinary can and contains water. The upper section has a bottom in the shape of an inverted funnel and rests on the lower one. Inside the upper section is placed a basket made of galvanized wire-cloth. The wax is placed in the basket and the machine placed on the stove. Steam is generated in the bottom, passes up through the hole in the center of the funnel shaped bottom of the upper section and comes in contact with the comb in the basket. The wax in the comb melts and runs down and out of a spout into a pan containing water. The Swiss extractor was used without pressure and the result shows an increase in efficiency caused by the use of pressure in wax extraction. The Swiss extractor can be used in connection with a press by putting the comb in a sack and transferring it to the press, but this method gives the wax a chance to cool and is not as efficient as some of the others.

Remelting Test. The results given above are for the wax as it comes out of the extractor. It was thought that it might be well to determine the amount of dirt in the different samples of wax. The wax used was that obtained in some of the preceding experiments with the Ferris, Swiss and solar extractors.

The wax obtained from each extractor was broken into small pieces, the sample thoroughly mixed, and a separate portion weighed and remelted in each of the four extractors. The wax from the steam extractor was allowed to drop from the spout into a dish of water on a water bath. The heat of the water in the water bath kept the wax melted and the dirt settled to the bottom. Owing to the lateness of the season the wax in the pans of the solar extractors did not remain melted. To have the conditions as near as possible the same as in the steam extraction, the wax from the solar extractors was put in a dish on the water bath, heated and the dirt allowed to settle. In both cases the dirt which had settled to the bottom of the cake was trimmed off and remelted over a water bath. This process was continued until all of the dirt was removed. The percentage of clean wax obtained was, for the solar extractor number one, 94.66, the solar number two, 96.19; the Ferris, 96.31, and the Swiss, 94.38.

Pressing Under Water. The comb, with some water, was put in a tub on the stove and the wax allowed to melt, but not to boil. A can was placed under a press and a slatted follower placed in the bottom of the can. Above this was placed a burlap bag and the hot water, melted wax and comb were poured into the bag, the top of the bag folded over, a slatted follower placed on top and pressure applied by means of a screw. After some of the wax had been forced out, the water and wax were drawn off, the pressure relieved, the slumgum stirred, hot water added and pressure applied again. The can, which fits under the press, has two holes which are stopped by corks. One is at the bottom and the

other near the top. By pulling the cork out of the upper hole the wax which has risen to the top can be drawn off and by using the lower hole all of the wax and water can be removed. The whole apparatus must be kept as warm as possible. An inside can with holes in the sides was tried but did not give good results.

In the following, average results are given because in the first two trials some of the wax adhered to the bag and follower. This method proved very efficient, giving about one per cent. more wax than the Root extractor with number two comb and about six per cent. more with number three comb. The main points in this method were received from Mr. Gill of Longmont, Colo., whose method is somewhat similar except that in his case the wax was dipped from a boiler and placed in the press.

Sulphuric Acid and Pressure Under Water. It was thought that the addition of acid to the water in the experiment might increase the efficiency of the method. The comb was heated in a porcelain lined tub with a solution of five per cent. commercial sulphuric acid. When the wax had melted it was poured into the sack in the press and pressure applied quickly in order not to have the acid in contact with the metal any longer than necessary. The wax and water were drawn off, boiling water added, the slumgum stirred and pressure applied again. This water was drawn off and put with the rest. As this was an experiment to determine the efficiency of the press a tin can was used, but in practical work it would be necessary to have everything acid proof, as hot acid even when diluted, is very destructive to most substances. The can could be made of wood or porcelain lined ware. The latter would probably be the better.

This method was easy to manipulate and rapid and was the most efficient of all the methods used. This method gave about seven per cent. more wax for number two comb and seven per cent. more for number three comb than did the Root extractor.

Comparison of Different Methods. The following table shows the efficiency of all methods with combs number two and three and are average results. Number one comb was not used in all the extractors because most methods give good results with new clean comb:

	Result in Percent. Comb. No. 2	Comb. No. 3
Solar extractor, single glass	31.02	10.24
Solar extractor, double glass	38.27	12.79
Swiss steam extractor	48.59	21.30
Ferris steam extractor	58.02	25.60
Root steam extractor	59.43	37.83
Pressure under water	60.55	44.42
Pressure under water with sulphuric acid	67.02	45.19

COLOR OF THE WAX.

The wax produced by the Root, Ferris or Swiss extractor did not have a good color and would have had to be refined before it could be used. The wax from the solar extractors was always a better color than

that from the steam extractors. The wax formed by pressure under water was nearly as good in color as the wax from the solar extractors. The wax obtained by pressure under water containing five per cent. of sulphuric acid was very good in color, in fact, almost as good (with combs number two and three) as most of the wax obtained from the solar extractors.

I believe the color of the wax from the steam extractors to be due to the presence of iron, owing to the metal in the extractor coming in contact with the steam. The wax from the Ferris and Root extractors was tested and showed the presence of small quantities of iron; enough perhaps to account for the color. The wax from the solar extractors did not show the presence of any iron.

Bleaching Wax. In a search for a method for bleaching beeswax I found many compounds which would effectually bleach the wax, but most of them either destroyed the wax or were in themselves poisonous. Chlorine, which is a great bleaching agent, cannot be used on account of its forming, according to Allen, chlorination substitution—products which may give rise to hydrochloric acid. Beeswax can be volatilized almost without change in a vacuum but when distilled under ordinary pressure it yields a variety of products. Therefore this method cannot be used in purifying beeswax.

The principal use of beeswax is in the manufacture of comb foundation which is given to the bees to act as a foundation on which to build their comb. In order to get nice, white honey the foundation must be light colored. The following experiments were made to determine the best method for cleaning and bleaching wax.

Acids Used in Bleaching. The beeswax on which this experiment was made was a sample of wax that had been rendered from dark colored comb. It was heated in water so as to get a uniform cake, which was cut into eight equal pieces and one piece taken for each test.

Piece number one was heated with 2 cc. of sulfuric acid and 200 cc. of water. Piece number two was heated with 2 cc. of hydrochloric acid and 200 cc. of water. Piece number three was heated with 2 cc. of nitric acid and 200 cc. of water. Piece number four was heated with 200 cc. of water. Piece number five was heated with 200 cc. of water and 2 cc. of a solution containing 60 cc. of sulfuric acid and 63 grams of potassium bichromate to 1000 cc. of water. Piece number six was heated with 200 cc. of water and 5 grams of sodium chloride or common salt. Piece number seven was heated with 100 cc. of the solution of sulfuric acid and potassium bichromate which was used with number five, mixed with 200 cc. of water. They were all cooled in the air and stood over water while cooling. Number one gave the best results and the wax was lighter colored than any of the others. Numbers two, three, five and six did not show much improvement over number four which was used as a blank for comparison. Number seven gave a very dark green wax.

This would go to show that as far as bleaching and removing the coloring matter, the sulphuric acid gives the best results of the materials used.

Sulphuric Acid and Hydrogen Peroxide. For this experiment a sample of dark wax which had been obtained from brood comb was used.

It was melted in hot water, formed into a cake, the cake cut in eight equal pieces and the pieces treated in the following manner:

Piece number one was heated with 100 cc. of water.

Piece number two was heated with 100 cc. of water and 2 cc. of sulfuric acid. Piece number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number four was heated with 100 cc. of water, 10 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number five was heated with 100 cc. of water, 15 cc. hydrogen peroxide and 2 cc. of sulfuric acid. Piece number six was heated with 100 cc. of water, 20 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number seven was heated with 100 cc. of water, 25 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number eight was heated with 100 cc. of water and 5 grams of oxalic acid. Piece number three, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc of sulphuric acid, was much better than any of the others. Hydrogen peroxide was tested for and found in the water in which the wax had been melted. Excessive boiling with water seemed to injure the grain of the wax, but the heating with water and sulfuric acid and with water, sulfuric acid and hydrogen peroxide did not seem to injure the grain. Piece number eight showed only a slight improvement over the original sample.

Remelting with Sulphuric Acid and Hydrogen Peroxide. One-half of piece number three of the last experiment was remelted in 100 cc. of water, 2 cc. of sulfuric acid and 5 cc. of hydrogen peroxide. The color of the wax was very much lighter than before being remelted in 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc. of sulfuric acid. The wax was pressed out of the cloth and was very much improved. It had a golden yellow color and a good grain.

Increasing the Amount of Sulfuric Acid. The wax used in this experiment was dark and was obtained by rendering old combs. It was remelted and divided into eight equal parts. Number one was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Number two was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc, of sulfuric acid. Number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 10 cc. of sulfuric acid. Number four was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 15 cc. of sulfuric acid. Number five was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 20 cc. of sulfuric acid. Number six was the same as number five except that it was heated with 25 cc. of sulfuric acid. Number seven was inclosed in a canton flannel bag, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid, and the wax squeezed out of the bag. Number eight was heated with 100 cc. of water. Number two gave better results than any of the others with the exception of number seven, which gave a very nice yellow wax.

Refining with Alcohol. The wax taken for this experiment was obtained by rendering old brood combs and was dark. It was remelted and divided into eight pieces. Number one was heated on the water bath with 100 cc. of barrel alcohol. Number two was heated on the water bath with 50 cc. of alcohol and 50 cc. of water. Number three was heated in the same manner as number two with 25 cc. of alcohol and 75 cc. of water. Number four, one-fourth of number one, was heated in water. In number one the wax dissolved and on cooling cerotic acid separated from the alcohol. In numbers two and three there did not seem to be any cerotic acid dissolved in the liquids. Number one gave a soft waxy substance, probably myricine. Number four gave a compact substance. Number five was as good in appearance and texture as any of the others. I could not see any improvement in the color of the wax caused by the treatment with alcohol.

The use of Cloth in Refining Wax. The wax used for this experiment was very dark and was divided into four equal parts. Piece number one

was inclosed in a piece of fine canton flannel cloth and heated in water which contained five per cent of sulfuric acid and five per cent of hydrogen peroxide. Number two was inclosed in a piece of fine canton flannel and heated in a solution of five per cent sulfuric acid. Number three was inclosed in a piece of coarse linen cloth and heated in a solution containing five per cent sulfuric acid and five per cent hydrogen peroxide. Number four was inclosed in a piece of fine canton flannel and heated in water. Number one gave the best results. The wax had a good color and a good grain. Number two was next to the best. Number three was not as good as either number one or number two. Number four was used as a check. All showed improvement over number four.

One-half of number one was placed in a canton flannel cloth and heated with a solution containing five per cent sulfuric acid and five per cent hydrogen. One-half of this last sample was placed in a canton flannel cloth and heated twenty minutes with a solution containing two per cent sulfuric acid and five per cent hydrogen peroxide. Three-fourths of the last sample was placed in a canton flannel cloth and heated with a solution containing five per cent hydrogen peroxide and two per cent sulfuric acid. The last sample was remelted in the same manner and the color could not be improved. The last two heatings did not seem to improve the color of the wax. The one before them, number two, gave the best colored wax and the wax had a good grain.

EXAMINATION OF THE SLUMGUM.

As stated under the properties of wax, the wax contains on an average of about 14.4% cerotic acid. There are two ways known for the determination of pure wax in impure beeswax. They both depend on the amount of cerotic acid in the wax which can be saponified in the presence of wood alcohol. Neither method is very satisfactory for dark colored wax. The amount of cerotic acid in the slumgum might be determined by one of these methods and the amount of wax in the slumgum estimated.

All of the slumgums gave cerotic acid and therefore contain some wax. I was unable to devise any method or modification of methods to determine the amount of cerotic acid in the slumgum. In the presence of so much coloring matter the indicators did not give good results.

Boiling with wood alcohol and decanting off the hot solution and titrating was tried, but was unsatisfactory. It was found that after boiling ten grams of slumgum with twelve portions of wood alcohol of 50 cc. each there still remained cerotic acid in the residue. The addition of hydrogen peroxide to the alcohol and slumgum did not cause an improvement. A red coloration was formed which covered the end reaction of the indicator.

SUMMARY.

In summing up the facts given in the preceding experiments, I draw the following conclusions:

In some ways the solar extractor is a good extractor for the beekeeper to have. It is convenient and requires very little attention. The solar extractor does not remove as much wax from the comb as the steam extractor. The residue, or slumgum, from the solar extractor may be worked over in the steam extractor and some wax obtained. The solar extractor can remove honey from the comb, but with ordinary comb and warm weather the honey is not of a very good quality.

The heat of the sun seems to bleach some kinds of wax, besides extracting it from the comb. In other cases it is difficult to notice any bleaching in wax which is exposed to the sun.

The steam wax extractor removes more dirt than the solar extractor. The steam extractor will remove honey from the comb, but the honey is usually very dark. In efficiency the steam extractor has an advantage of from ten to twenty per cent over the solar extractor.

In efficiency the solar wax extractor number two has a slight advantage over solar extractor number one, about one per cent for number one comb, for number two comb two per cent, and for number three comb about one per cent.

The addition of an extra pane of glass to the solar extractor raised the inside temperature on an average of 17 degrees F. The efficiency of the extractor was increased on an average about seven per cent. for number two comb and two per cent for number three comb.

The addition of a lamp to the solar extractor raised the efficiency of the extractor on an average about one per cent.

The addition of a lamp to the double glass extractor did not increase the efficiency of the extractor over 0.7 per cent.

Soaking the comb in water before using the solar extractor increased the yield of wax on an average, about one per cent.

The soaking of the comb in dilute (5 per cent) sulfuric acid increased the yield about five per cent over that not treated.

Of the steam wax extractors, the Root proved the best. The results show that for the same comb, number two, the Root produced one per cent more than the Ferris and ten per cent more than the Swiss.

Pressure applied to the comb under hot water gives a larger per cent wax than when the comb is pressed in steam. Heating with dilute sulfuric acid and pressing under water gave the best results. For number two comb this method excells in efficiency the single glass solar extractor by thirty-six per cent., the double glass solar by twenty-nine per cent., the Swiss steam wax extractor by eighteen per cent, the Ferris steam wax extractor by nine per cent, and the Root steam wax extractor by over seven per cent.

For number three comb, heating with dilute sulfuric acid and pressing under hot water, excells the single glass solar wax extractor by thirty-five per cent, the double glass solar wax extractor by about thirty-two per cent, the Swiss steam wax extractor by twenty-four per cent, the Ferris steam wax extractor by nineteen per cent, and the Root steam wax extractor by seven per cent.

The above shows that the slumgum from 100 pounds of wax treated by the ordinary solar wax extractor will retain from thirty-four to thirty-six pounds of wax, which can be removed by heating with dilute sulfuric acid and pressing under hot water. If the Root extractor, which is the best

of the steam wax extractors, is used there remains in the slumgum about seven pounds of wax which is obtainable by the use of the sulfuric acid and pressure. With the price of wax at twenty-five cents a pound it would pay to buy old slumgum and remove the wax by this method.

The method of heating the wax, while inclosed in a bag, with sulfuric acid, as practiced by more refiners of wax, gives good results.

Sulfuric acid seems to be better for bleaching wax than either hydrochloric acid, nitric acid, or a mixture of potassium bichromate and sulfuric acid. The wax from the latter has a dark green color which may be removed by repeated heating with oxalic acid. Oxalic acid is a poison and I am not prepared to state how much would be left in the wax or what effect it would have upon the bees working with the wax.

An increase of sulfuric acid above five per cent does not seem to improve the color of the wax.

The addition of five per cent of hydrogen peroxide to the sulfuric acid and water gives a much lighter colored wax. An increase of hydrogen peroxide above five per cent does not give an improvement in the color of the wax.

Common salt added to the water in which the wax is boiled does not cause the dirt to settle enough to show a change in the color of the wax.

Heating the wax, which has not been treated with sulfuric acid and potassium bichromate, with oxalic acid does not seem to improve the color of the wax.

Excessive boiling seems to injure the grain of the wax. The best results in regard to the grain of the wax were obtained by causing the wax to melt but not come to a boil.

Heating the wax while inclosed in a cloth and squeezing it after the wax has melted gives a much better colored wax than heating without the cloth. A fine canton flannel cloth with the nap inside is better than a coarse cloth. The nap seems to hold the dirt that is in the wax. Remelting the wax inclosed in a cloth with two per cent. solution of sulphuric acid and five per cent. hydrogen peroxide improves the color of the wax. Continued treatment in the same way does not give corresponding improvement in the color of wax. After the third treatment there is not any improvement in the color and rather a deterioration in the quality of the wax.

Boiling with concentrated and dilute alcohol does not improve the color of the wax.

The color of the wax is not improved by standing over water after cooling.

All of the slumgum retains some wax, but it was found impossible to determine the exact amount.

From the results of these experiments and my own experience in handling bees and rendering wax I believe that it is best for the average beekeeper to have a large solar wax extractor, heated by some artificial heat, by means of which most of the wax in the lighter colored combs, cappings, and burr combs may be easily rendered. The dark combs may also be treated in this manner and the slumgum stored in barrels until the beekeeper has time to treat it with dilute sulphuric acid and press under water. This method is quick and efficient. If the wax has to be refined it can be done by heating, while inclosed in a canton flannel sack, with a solution containing five per cent. of hydrogen peroxide and two to five per cent. of sulphuric acid. Both of these chemicals can be bought at the ordinary drug store. The common kind, commercial, should be used.

In mixing the acid and the water care should be taken to always pour the acid gently into the water and not the water into the acid.

The cost of the chemicals compared with the results obtained is very slight.

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BY

B. O. LONGYEAR

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MARGARET MURRAY,	Clerk

THE EVERGREEN TREES OF COLORADO

By B. O. LONGYEAR

At no time in the history of our country have matters pertaining to our forests been of such general interest as at the present. Such interest is certainly justified when we consider the fact that between three and four times as much timber is used by us each year as our forests can grow in the same length of time. Many of the materials which a few years ago were expected to become substitutes for wood have failed to meet the requirements in many ways. Moreover the continued use of wood for new purposes more than offsets the saving by these substitutes. Hence there is not only apprehension for the future supply of wood but even now certain great industries are being forced to limit their operations because of the scarcity of timber. This is particularly true of the timber from which paper pulp is manufactured.

In Colorado the principal drains upon the timber resources of the state have been to supply material for mining timbers, telegraph poles, railroad ties, fence posts, bridge timbers and native lumber. The growing scarcity of our timber trees is being emphasized by the rapid advance in price which is now felt in all industries requiring such material.

So long as the forests have been left to the disposition of private interests the forests have suffered greatly. The wasteful and careless methods of lumbering that have usually been employed in this country have frequently been followed by the consuming fire fiend. In these ways the larger part of our forest products have often failed to reach the markets but have served to darken the skies with the smoke of a sacrifice in which the gods have no pleasure. Not only have the trees themselves been destroyed but in many cases the burning away of the humus, the slow accumulation of centuries, has laid bare the very rocks and made reforestation impossible. But this is not all. The rapid and complete removal of the forests has in many places shown how great was their influence upon water movements. Thus with the removal of the forests that once surrounded the headwaters of our great streams, disastrous floods in spring and low water in summer have indicated the regulating effects which these forests once produced. In our own state the forests in the higher altitudes serve to check in spring the rapid melting of snow which has drifted among the trees and thereby lengthen the period of stream flow during the growing season.* The most important effects of the forests in this connection, however, are due to the character of the forest floor, which is

* For some of the effects see Bulletin 55, Colo. Exp. Sta.

composed of the decayed, castoff parts of the trees themselves. This layer of humus material possesses the ability to absorb water like a sponge and in this way check the rapid surface flow of water such as takes place on bare soil. Thus the water from melting snows and from heavy rains is held back to appear later from springs instead of rushing into the streams and giving rise to floods and high water.

NATIONAL FOREST RESERVES.

The extent of the forest reserves in this country indicates the importance which the government places upon the conservation of the forests. The first national forest reservation was established in 1891. On April 1, 1907, the total extent of the forest reserves in the United States comprised one hundred and fifty-three reserves with a grand total of nearly one hundred and forty-eight million acres. California stands at the head of the list with an area of nearly twenty-two million acres, while Colorado comes fifth with eighteen reserves covering nearly sixteen million acres. These vast tracts have not been set aside, however, to become unproductive holdings of the National Government. They are not even closed to the would-be settler on any agricultural lands within their boundaries nor to the prospector and miner in seeking and developing claims. Grazing lands within the forest reserves can still be used as such with the added protection to the industry which the small fee carries with it. Neither is it the primary object of the forest reserve idea to stop the cutting and sale of timber but to regulate it in such a way as to make the forests more productive. In fact, the primary purpose is to prevent wasteful and destructive practices of lumbering, to protect the forests from fire, their most destructive enemy, and to get them in a condition where reforestation may go on and thus make them a perpetual source of timber supply.

The principal forest trees of this state are those commonly known as evergreens. It is the purpose of the present bulletin to help familiarize the people of this state with our native evergreen trees and thereby strengthen the interest in their protection. Brief suggestions and directions are also given for their use in ornamenting the home grounds and in planting for wind-breaks and screens.

THE EVERGREENS.

In popular usage the term evergreen is applied to members of the pine or cone-bearing family of trees. This is due to the fact that most members of this family hold each season's crop of leaves during several years so that at no time are they bare of foliage. Some true cone-bearing trees, however, such as the larches, shed all their leaves each autumn the same as other deciduous trees. On the other hand, some of the broad-leaved trees and shrubs hold

their foliage in a green state over winter or even longer and are therefore true evergreens. This is particularly the case in tropical countries. But as all the cone-bearing trees of this state are evergreens the term as here used is intended to include members of the pine and juniper families only.

The plants of the pine family are chiefly characterized by the fact that their seeds, instead of being contained during all stages of growth in wholly closed seed cases, as in other seed-bearing plants, are at first born naked on the scales of cones. The scales of these cones become dry and more or less woody and hard according to their thickness and form the familiar dry, scaly cones of such trees.

Another character common to the plants of the pine family in this region is found in their needle-shaped leaves. These leaves, on account of the relatively small surface which they expose and the thickness of the epidermis which covers them, are well adapted to endure the drying effects of winter so trying to all kinds of perennial plants.

Most of the cone-bearing trees are possessed of a resinous juice or sap which often exudes from wounds and slowly hardens in the form of drops or masses of pitch. This material, when gathered from certain pines in the southeastern states, constitutes the crude turpentine from which the spirits of turpentine of commerce is obtained, the common resin or rosin being left as a residue. Timber from pine trees in which the wood has become saturated with the pitch of the sap possesses great durability in contact with the soil.

In most species of cone-bearing trees the two sorts of flowers, which are separate, occur on the same trees. The stamen flowers, those which produce the pollen, are crowded in small catkins or cone-like clusters near the ends of the branches. (Plate II, 1.) The pollen, in the form of a yellow powder, is abundantly produced and is carried by the wind to the young pistillate or seed-bearing cones. In the vicinity of extensive spruce and pine forests this pollen powder is often so abundant, during the blossoming period, as to lend the impression that a shower of sulphur has occurred. Soon after the pollen is shed these little cones dry up and fall off, hence are not commonly noticed.

The pistillate or seed-bearing cone consists of an axis upon which are fastened the scales. The scales vary much in shape and texture in different species and furnish some of the principal characters by which the species are distinguished. At the base of each scale of the young cone, and lying attached to its upper surface, is a pair of ovules. During the flowering period the young cones point upward with the scales spread apart. This allows some of

the pollen grains, with which the air may be filled at this period, to slip down to the base of the scales, where they come in contact with the waiting ovules. In a few days the scales close together and the process of fertilization later takes place. This is soon followed by the growth in size of the cones and the development of an embryo within each ovule by which it becomes a seed. (Plate I and II A.)

In some species, e. g., the pines, the scales of the cones remain closed during the whole of the first year and mature their seeds in the second year. In others, such as the spruces, the seeds are matured and dropped at the end of the first season.

In the juniper family, which is closely related to the pine family, these seed-bearing scales become fleshy and united as the cones ripen so that the matured seeds are found imbedded in the pulp of the berry-like fruits.

TRANSPLANTING EVERGREENS.

The root system of the cone-bearing trees is often very extensive, especially in trees that have reached some age, and have grown all their lives undisturbed as in nature. The roots are, moreover, very sensitive to drying and, on account of the resinous character of the sap, when once dry they cannot be revived by soaking. Then, too, an evergreen always has leaves which are continually giving off some moisture, hence at no time can these trees be without moisture at the roots without suffering injury. These facts usually account for the lack of success which so many persons experience in transplanting evergreens. The writer has seen young evergreen trees that had been carelessly dug or even pulled from the soil among the hills, where they had become deeply rooted, and then carried for miles with no protection whatever to the roots. A cottonwood, boxelder or black locust might survive such treatment, but an evergreen should never be expected to grow when handled in this manner.

USE OF FOREST GROWN SEEDLINGS.

The fact that the roots of evergreens are usually slender and that they quickly extend with but little branching to considerable distances, when undisturbed, makes the transplanting of forest grown trees an uncertain matter. This is especially true when trees of some size are being moved by the usual methods. Native forest seedlings are, however, often made use of in forest planting and the same can be done for other uses providing that the small seedlings only are moved. The best time for this work is just as the buds are beginning to swell in spring but before the new growth is out. Somewhat later transplanting can, however, be done with extra care. Such seedlings should not be over ten inches in height

to bear transplanting well, and smaller sizes are better. They should be carefully lifted from the soil with a spade in such a way as to retain as many of the roots as possible. A pail or tub with two or three inches of thin mud or puddle in the bottom should be at hand, into which the roots of the little trees are to be at once placed. If they are to be planted again in a few hours the seedlings may be carried in this condition. But where large numbers are being gathered and where a considerable journey is necessary, the trees may be closely packed, roots down, in boxes, using moist sphagnum moss, fine grass or similar material among the roots. The boxes should be covered, if placed in an open vehicle, for the journey. If the trees are not to be planted out at once they may be heeled in for a few days. This consists of placing the roots in a broad trench with the trees leaning against one side, after which moist soil is shoveled over them until the trees are about half buried. A shady place should be selected for this purpose.

Trees of such small size are usually grown for two or more years in nursery rows or until one to two feet high. In this way they can usually be given much better care than when placed in the wind-break or other permanent quarters. They should be planted in rows about eighteen inches apart and six to eight inches apart in the row for the small sizes.

Transplanting is best accomplished by laying a wide board upon the surface of the soil and then opening a trench along one edge with a spade. The little trees are then planted against the perpendicular side of the trench and moist soil firmly packed about the roots. The trench should be made only a few minutes before planting to avoid drying of the soil, and the trees should be carried in a pail containing a little water. If possible, select a cloudy day for this work and when the soil is moist but not wet. The soil should not be allowed to bake at any time. Careful cultivation must be maintained during the earlier half or two-thirds of the growing season and a winter mulch of coarse manure or straw is desirable.

In transplanting larger trees the same care must be observed as with small ones. It is often possible, in moving them only a short distance, to retain the earth surrounding the roots in a ball. Thorough packing of the soil about the roots should be practiced except where the soil is very sticky or wet.

It is usually desirable to give the nursery partial shade during the first season. This may be accomplished by lath screens supported on stakes about one foot high. Brush laid across wooden bars or wires stretched along the rows may also be used.

NURSERY GROWN STOCK.

This is always to be preferred where only a few trees are

wanted and where one has no time to grow them from seedlings. Nursery grown trees, if properly handled, have been transplanted one or more times. This causes the root system to thicken up, or become condensed in a relatively small space, and thus makes it possible to secure practically all of the roots in a compact mass when dug. Some nurserymen, who make a specialty of growing evergreen stock, furnish trees each with a ball of earth which contains most of the roots and enables one to plant them with confidence. Trees up to eight feet in height may in this way be safely shipped and transplanted, but, of course, they are correspondingly expensive.

Nursery grown seedlings four to ten inches high and one to three years old can be purchased in quantity from the leading nurserymen and are often cheaper than forest grown seedlings if one considers the time and labor required to obtain the latter. Nursery grown stock, whether in seedling or larger sizes, is usually cheaper in the end than forest trees for, not only are the trees more apt to live, but, having been adapted to conditions in the open, they are surer to make a rapid and healthy growth.

THE PROPER TIME TO TRANSPLANT EVERGREENS.

It is generally recommended that evergreens are best transplanted in spring. This is particularly the case in a climate like that which prevails in Colorado. Fall planting is claimed to be satisfactory by some nurserymen and it may prove successful in other climates. But the lack of soil moisture which often prevails here in the winter season, together with the drying winter winds, makes fall planting a very hazardous undertaking. Trees of this class will often bear later transplanting than other kinds. The proper time, however, is when the buds are swelling, as at this time the vital processes of the tree are just commencing. Hence new root growth is taking place which will enable the tree to secure water from the soil and to become established.

PRUNING.

It is seldom necessary to prune carefully dug nursery grown evergreens, when they are transplanted, unless it is desired to change their shape. The same is true of seedling trees, even forest grown.

In transplanting forest grown trees of more than one foot in height it may be desirable to cut back the limbs one-third to reduce the loss of moisture from the leaves.

It is best to preserve the terminal bud, as this gives rise to the leader or main stem. If by any means this bud is destroyed it sometimes occurs that two or three of the next lower whorl of buds will push up equally strong shoots. In this case all but one should

be pinched back or cut off and the remaining one be tied erect to the stub of the leader.

EVERGREENS ON THE LAWN.

Among the evergreen trees of Colorado are to be found some of our most ornamental trees for the home grounds. If rightly placed and properly planted so as to secure a healthy growth they are capable of adding, not merely to the foliage effects of summer, but they also lend a pleasing touch of green to the winter landscape.

They are best situated along the borders of the grounds, where they may form a background for shrubs and flowering plants. Specimen trees should not be freely used, as a rule, except on large grounds. They should be placed at a sufficient distance from other trees so that they can spread out naturally. If planted in sodded ground the sod should be removed and a circle of bare earth four or five feet across, kept well cultivated around each tree for several years. A great many evergreen trees, as well as other kinds, are needlessly lost every year by planting them in sod where they must compete with the grass.

In the pruning of old trees one should hesitate to cut off the limbs close to the trunk if it is expected that new ones will start out as in many of the deciduous trees. The usual manner of pruning evergreens up from the ground for several feet is much to be deplored, especially in the case of specimen trees on the lawn. The beauty of most evergreens in such situations is dependent on their being allowed to develop a natural form with the lower branches extending clear to the ground. This practice of trimming off the lower branches is most often due to planting evergreens where they eventually shut off the light or the view. Thus it is advisable to plan well in advance the position of each tree about the house and to take into account the effects of future growth. If trees of this class are planted on the south side and close to the dwelling there will eventually be an undesirable shading of the house in winter on the side where the sunshine at that season is most available.

Then, too, the planting of evergreens before the front windows is sure in time to give rise to the necessity of trimming the trees up from the bottom, removing them entirely or else leaving them to darken the rooms and obstruct the view. Where privacy and seclusion are sought, however, evergreens are well suited to such purposes. Thus they may be used to screen or hide unsightly places or objects and are splendidly adapted for planting around outbuildings.

EVERGREENS FOR WINDBREAKS.

Evergreens are among the most effective trees for windbreaks. They are especially desirable for giving shelter from cold winds in winter to sheds and barns and yards for stock. They are also desirable to plant around the outside of the deciduous timber plantation to check the sweep of winds which carry away the snow and fallen leaves. Seedling trees which have been twice transplanted and are about one foot high are of a suitable size for this purpose. They should be set far enough apart to allow each tree to spread out without crowding and eventual loss of the lower limbs. Eight or ten feet apart is about as close as such trees as pines and spruces should be planted. If more than one row is used the trees should alternate in the rows and the rows be at least twelve feet apart. Where a low hedge-like effect is desired much closer planting may be done, and the trees cut back when at the proper height.

Thorough cultivation is needed until the trees are well established or as long as there is sufficient room between the rows.

Evergreens can often be established with good results among deciduous trees planted for windbreaks. In fact, many species of evergreens cannot be readily grown during the seedling stages except in partial shade, hence the desirability of shading the young plants in the nursery.

Close shading, however, should not be allowed to continue after the trees have reached a height of four or five feet. Otherwise the trees are apt to lose their lower branches and become spindling, thus greatly reducing their effective windbreak character. If the surrounding trees become too tall and dense they should be thinned out or cut back to give the slower growing evergreens a better chance.

RAISING EVERGREENS FROM SEED.

This is work which is most successfully undertaken by nurserymen or other persons of experience. For those who have time and the necessary patience to wait for several years while the seedlings are growing this is not only a cheap way to secure a large amount of stock, but is also very interesting work. Seeds of most evergreens can usually be purchased from the large seed houses. Where possible, however, it is desirable to save them from native or local growing trees which show the best color, form and hardiness. Seeds of the pines and spruces are best harvested by gathering the cones a little while before they open. When dry, in most cases the scales spread apart and allow the seeds to be readily threshed out. The cones of the lodge pole pine, however, often do not open unless heated to 100 to 150 degrees

Fahrenheit. This may be done on a wire screen placed above a stove, or in an oven.

In the case of junipers and red cedars the berries when ripe should be gathered and soaked for twenty-four hours in strong lye made from wood ashes, and rubbed on a fine sieve to remove the pulp. They should then be stratified by mixing them with moist sand which is to be kept in a box or other receptacle left where freezing will take place. They will not usually grow until the second season.

The seed bed for raising conifers should be on light, porous soil with good underdrainage, but which can be kept from drying out. If only a small number are to be grown good garden soil can be suitably prepared by mixing a considerable proportion of fine sand with the surface two or three inches. If the soil is naturally sandy this would not be necessary.

Beds about four feet wide may be laid off and the seeds sown broadcast or in drills or rows, scattering them about as thickly as with radish or onion seed, for the smaller kinds, and about one inch apart for the larger kinds. The planting is usually done in May, the seeds being covered to a depth of ¼ to ½ inches, depending on their size.

If the soil is at all heavy or loamy in character a layer of fine sand should be scattered over the bed to a depth of one-fourth inch. The soil should be moist but not wet when the seeds are sown and the surface must be kept finely pulverized. Where the atmosphere is very dry it is often possible to retain the soil moisture by covering the beds with burlap fastened down with pegs. This will admit the sprinkling of the beds with a watering pot without washing the soil or disturbing the seeds. The burlap covering must be removed as soon as the seedlings begin to break through the soil.

Most evergreens require partial shade during the first two or three years of growth from seed. This is usually accomplished by means of lath screens placed six feet above the beds, the lath being laid about one and one-half inches apart. In place of lath brush may be used laid on a framework of poles supported on posts of the proper height. Although free circulation of air must be given across the evergreen seed bed the seedlings should be protected from strong winds either by lath screens or by brush stuck firmly into the ground around the sides of the bed. Boards ten or twelve inches wide set on edge around the edge of the beds will furnish excellent protection from surface wind-sweep and consequent rapid drying out of the soil.

An excellent plan to follow in raising coniferous seedlings is to inclose the seed beds with twelve-inch boards placed on edge,

making the beds four feet wide and as long as desired. The soil within the bed should be one or two inches higher than that outside the frame. After the soil is carefully leveled and firmed with a piece of board the seeds are sown broadcast and covered to the proper depth by sprinkling fine soil upon them. Lath screens are then laid across the bed and allowed to rest upon the board frame. In this way trouble from strong winds, which might blow down the high screens, is avoided and moisture is readily retained. On cloudy days the screens should be removed, especially while the seedlings are young.

If an open place among trees and in partial shade is available the artificial screen may be omitted. Care should be taken to keep the surface of the soil comparatively dry, for a wet, soggy soil is almost certain to induce "damping off," a disease caused by certain fungi which thrive in poorly drained soils. A thin layer of pure sand spread over the surface of the soil is often used to check or prevent this trouble.

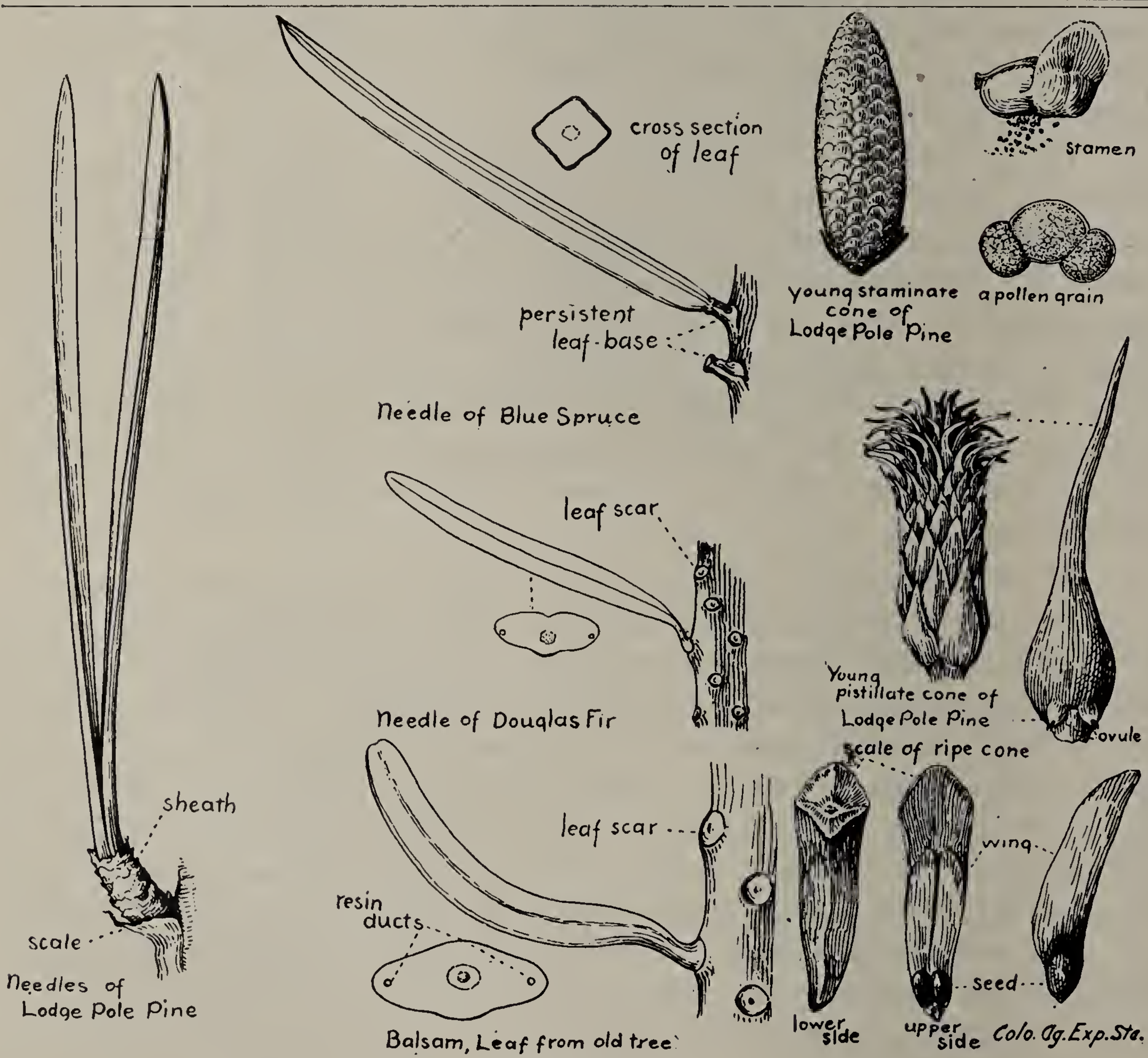

PLATE I.

Drawings showing leaf-characters that distinguish the pines, spruces and firs; also the flowers (young cones) of a pine, all somewhat enlarged.

On the approach of winter the bed of seedlings should be mulched with straw, leaves or evergreen boughs, which will protect the little trees from the injuries of alternate freezing and thawing. In the spring the mulch should be removed a little while before growth begins and careful cultivation with a fine toothed rake be given. At the age of two years the seedlings should be transplanted four to six inches apart in nursery rows as recommended for forest grown seedlings. They will in most cases be too small to transplant to permanent quarters until four years old.

SPECIES OF EVERGREEN TREES IN COLORADO.

The evergreen trees native to this state belong in two families—the pine family and the juniper family. The two families as they occur here may be distinguished by the following characters:

Pine Family.—Foliage leaves needle-shaped; single or in bundles of two to five; fruit a dry, scaly cone; seeds usually furnished with a thin wing.

Juniper Family.—Leaves awl-shaped or scale-shaped, in the latter case entirely covering the twigs; fruit berry-like, juicy or nearly dry; seeds usually without wings.

Of the thirteen evergreens occurring in Colorado which grow to the stature of trees ten belong in the pine family.

Pinaceae—PINE FAMILY.

(Plate I.)

KEY TO THE COLORADO GENERA.

I. Needles in tufts or bundles of two to five, mostly more than 25 m m. (1 in.) long, surrounded at base by a short sheath; cone scales thick, hard and woody when mature.

1. Genus Pinus.

II. Needles single, mostly less than 25 m m. (1 in.) long. Cone scales thin, leathery or papery when mature.

A. Needles in our species stiff and four angled, each one jointed to a short, hard, brownish base; branchlets rough from the prominent leaf bases which remain long after the upper part has fallen; cones pendulous, with persistent scales.

2. Genus Picea.

B. Needles flat, without hard, persistent bases, falling entirely away and leaving rounded scars; branchlets from which the leaves have fallen quite smooth.

a. Needles with a narrowed or stalk-like base, scars small, elliptical across the branchlets; cones pendulous, feathered with projecting, three-pointed bracts.

3. Genus Pseudotsuga.

b. Needles not narrowed at base, scars quite large, circular in outline; cones erect, dark purple or blackish, the scales falling separately from the axis.

4. Genus Abies.

GENUS *Pinus*—THE PINES.

The pines form the most important group of the cone-bearing trees. As indicated in the key they are most easily recognized by the needles being in bundles of two or more with a short sheath at the base. This sheath, together with the needles which it surrounds at the base, grows from a very short twig which arises just above a small, brownish scale that also represents a form of leaf. The staminate flowers occur in small cone-like clusters crowded around the stems at the base of the new growth of the season. After the blossoming, which occurs quite early in the growing season of the tree, the staminate flower clusters dry up and fall off and thus leave a bare space on the branch which bore them. The pistillate or seed-bearing cones appear near the tips or along the sides of the new growth. At first they are small and are usually overlooked. After the blossoming period they develop rather slowly and do not mature their seeds until the second autumn. The scales of the cone are thick and hard and in some species each is furnished with a sharp curved prickle. Two seeds are borne at the base of each scale. As the seed matures a part of the scale peels off wtih the seed and forms its wing.

KEY TO THE COLORADO SPECIES OF PINUS.

I. Needles, five in a bundle.
- a. Scales of the cone tipped with curved prickles.
  - 1. *Pinus aristata.*
- b. Scales of the cone without prickles.
  - 2. *Pinus flexilis.*

II. Needles two to three in a bundle.
- A. Needles 8-12.5 c. m. (3-5 in.) long.
  - 3. *Pinus scopulorum.*
- B. Needles not over 6 c. m. (2⅜ in.) long.
  - a. Needles 3-6 c. m. (1¼-2⅜ in.) long; seeds small, 4-5 m m. (5/16 in.) long.
    - 4. *Pinus Murrayana.*
  - b. Needles 2-4 c. m. (¾-1½ in.) long; seeds large, 10-15 m m. (⅜-⅝ in.) long.
    - 5. *Pinus edulis,*

FOXTAIL PINE, HICKORY PINE.

(*Pinus aristata,* Engelm.)

(Plate II B)

The foxtail pine occurs chiefly in the higher altitudes among the mountains of central and southern Colorado, in Utah, Nevada and southern California and Arizona. It is a small or medium sized tree of bushy habit, seldom reaching a height of 12-15m. The short needles grow in bundles of five closely crowded along

PLATE II.

A. Flowers or young cones of lodge pole pine.
   1. Staminate flower-clusters.
   2. Pistillate cones on new growth.

B. Branch and cone of Foxtail pine.

the branchlets in brush-like tufts. The cones are about 8 cm. long and each scale is furnished at the tip with a slender curved bristle. On the branches of young trees the bark is at first smooth and milky white. On trunks of older trees the bark becomes irregularly divided into small scales of a brownish color. The wood is soft and light and possesses but little strength. It is sometimes used for mine timbers and fuel.

This tree is of but little commercial importance and its slow growth does not recommend it for planting where quick effects are desired.

LIMBER PINE, ROCKY MOUNTAIN OR WESTERN WHITE PINE.

(*Pinus flexilis,* James; *Apinus flexilis.* Colo, Exp. Station Bulletin 100, Rydberg.)

(Plate III.)

The common name of this pine is suggested by the long, lateral branches which are quite stout and enable this tree to survive in the windswept situations which it usually inhabits. It is of low topped form and stout trunk and occurs often at high altitudes in rocky, exposed places. The needles grow in bundles of five and are about 5 cm. long. At a little distance this tree resembles the foxtail pine, but is readily distinguishable from the latter species by the cones. Those of the limber pine are composed of numerous rather thin scales entirely free from prickles. The seeds are large and approach in size those of the pinion pine. In fact, this pine is not infrequently mistaken for the true pinon. It is readily distinguished by the fact that the needles of the pinon are in bundles of two instead of five as in this species.

The bark of the young branches and stems is smooth, light gray or white, becoming deeply fissured and dark brown or nearly black on old trunks. The light, soft wood is sometimes used for lumber, but is sure to be full of knots.

The limber pine is quite widely distributed, occurring along the eastern slope of the Rockies from Alberta to western Texas and southern California. Its largest size, occasionally 15-20 m. high, is reached in northern New Mexico and Arizona. In Colorado this pine is scattered throughout the higher portions of the mountains.

The limber pine is adapted to planting as an ornamental tree where large size is not desired.

Its hardy character enables it to thrive under cultivation and when thus grown it forms a tree of compact form and pleasing appearance. It is worthy of a place in the home grounds.

BULL PINE, ROCKY MOUNTAIN OR WESTERN YELLOW PINE, ROCK PINE.

(*Pinus scopulorum* (Engelm.) Lemmon)

(Plate IV.)

This is the largest of our pines and forms the prinicpal evergreen of the foothills and ridges along the mountain ranges and in the mountain parks. Outside this state it occurs in western Nebraska and from Montana to Arizona and New Mexico. On the Colorado plateau this tree forms the most extensive pine forests on the continent. From northwestern Nebraska

PLATE III.
Needles, cone and tree of Limber pine.

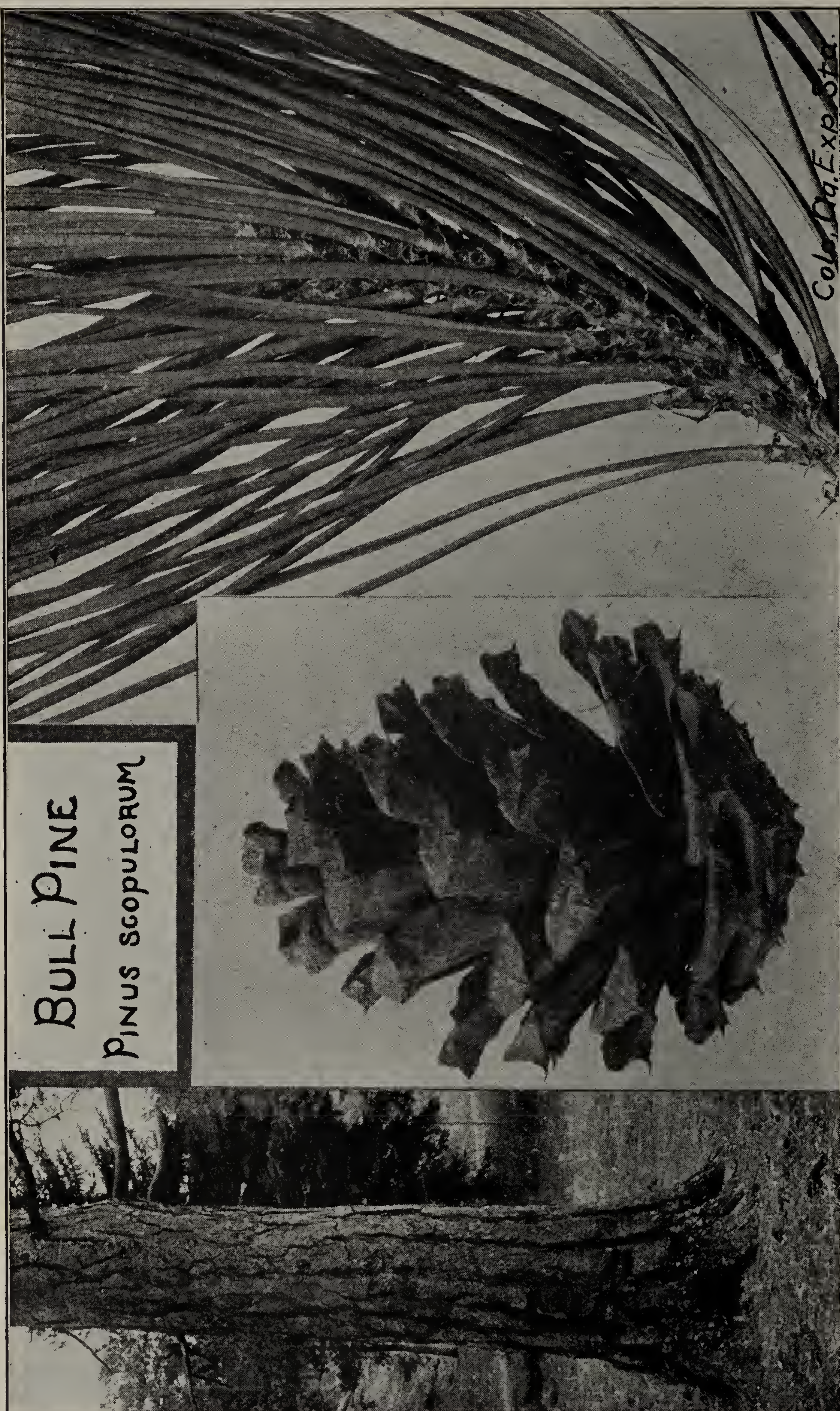

PLATE IV.
Trunk, cone and needles of Bull pine.

and western Texas to the Pacific Ocean and from southern British Columbia to southern California and Mexico this pine is replaced by the species pinus ponderosa, of which it is often considered as the variety scopulorum.

In Colorado the bull or rock pine forms rather open woods or forests on the slopes of valleys. Here it grows to a height of 24-30 m. (80-100 ft.) high and 1 m. (40 in.) in diameter. On the exposed rocky ridges and slopes it forms a spreading tree of stocky growth. The dark green needles are in bundles of two to three and vary in length from three to six inches. The cones are two to three inches long and the scales are tipped with stout recurved prickles, which on old cones are often missing. On large limbs and trunks the bark is blackish or cinnamon colored and on old trunks becomes thick and deeply furrowed. The wood is heavy and strong, but differs much in quality and is apt to be quite knotty. Its main uses are for lumber, railway ties and mine timbers.

This pine, on account of its deep growing root system, is able to resist drought better than almost any other of our evergreens. Thus it is well adapted to planting on the semi-arid plains and in dry, exposed situations. Under cultivation it is capable of rapid growth in diameter. A tree on the Agricultural College campus has averaged nearly one inch increase in diameter for each two years, the diameter when cut being seven inches at breast height, and with fifteen annual rings of growth. This rate of growth suggests this as a suitable pine for the tree plantation. When planted for lumber the trees may be planted twelve feet apart each way and the lower limbs be pruned off to form clean trunks as the trees grow in height.

This pine is quite easily grown from seeds, which are of good size, and which germinate readily.

(See directions for growing evergreens from seed).

The seedlings do not require shading when young as in the case of most evergreens. They should be transplanted when one or two years old to increase the number of fibrous roots. When four years old they may be set in permanent quarters if growth has been good.

LODGE POLE PINE, BLACK PINE.

(*Pinus Murrayana,* Oreg. Com.)

(Plate V. a. c.)

The lodge pole pine, so named from the use which the Indians once made of it in building their lodges, is a common evergreen in the hills and mountains of the northwestern states. It usually prefers northern slopes, which it covers with a dense growth. The trees are tall and straight and carry most of the foliage toward the top, especially when growing in forests. At a distance masses of this tree are noticeable on account of the yellow green of the foliage. It usually reaches higher altitudes than the rock pine. The needles are in bundles of two and are about two inches in length. The cones nearly equal the leaves in length and are composed of thick, hard scales, each of which is tipped with a slender prickle. The cones often remain closed and attached to the limbs sometimes for many years so that they occasionally become entirely overgrown by the enlarging stem.

A strong heat will cause the cones to open and allow the seeds to fall out. As the seeds may retain their vitality in the closed cones, sometimes for twenty years, a quick forest fire often brings about a reseeding of the burned district where this tree grew, by causing these old, "tight" cones to open.

The wood of the lodge pole pine is soft, light, and lacks durability. It is used to some extent for lumber, railway ties, mine timbers and fuel. The wood, when properly seasoned and treated with preservatives, is greatly improved in durability.

PLATE V.

a. c. Needles and cones of Lodge pole pine.

b. d. Needles and cone of Pinon pine.

PLATE VI.
a. c. Engelmann spruce tree and foliage.
b. e. Douglass fir tree and foliage.
d. Foliage of Blue spruce.

PLATE VII.

Immature cone, foliage and trunk of Balsam fir (Abies lasiocarpa)

PLATE VIII.

Group of Colorado Blue spruce.

1. Branch showing scale-like leaves and berries of Rocky Mountain Red cedar (natural size).
2. Branch showing awl-shaped leaves and berries of low Juniper, (natural size).

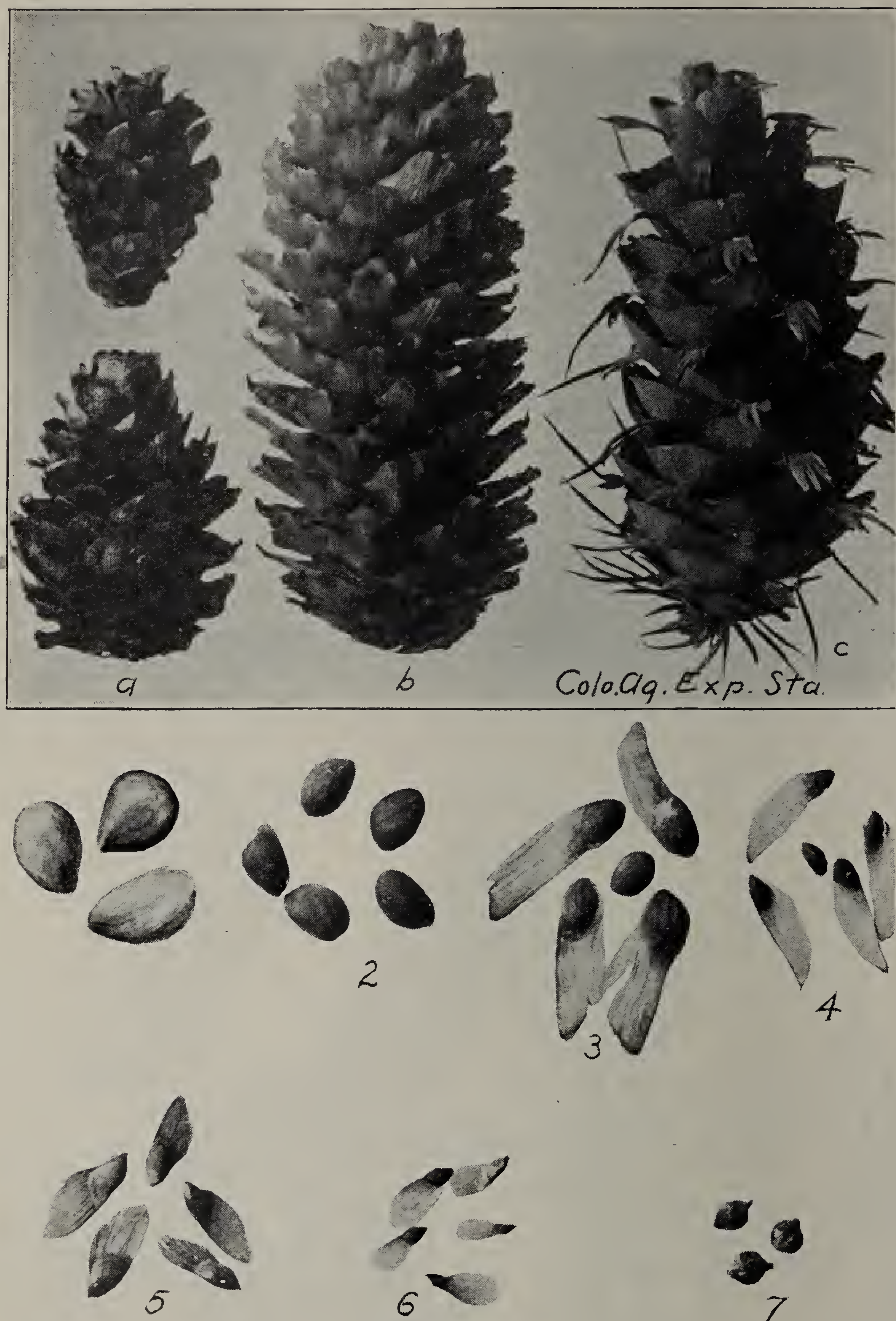

PLATE IX.

a. Cones of Engleman spruce.
b. Cone of Blue spruce.
c. Cone of Douglass fir.
1. Seeds of Pinon pine.
2. Seeds of Limber pine.
3. Seeds of Bull pine.
4. Seeds of Lodge Pole Pine.
5. Seeds of Douglass fir.
6. Seeds of Blue spruce.
7. Seeds of Red cedar.

(all natural size)

The lodge pole pine is capable of making a rapid growth under favorable conditions. It prefers a moist soil and may be used in the wind-break where such conditions prevail. When well established, however, it is hardy and enduring.

PINON, NUT PINE.

(*Pinus Edulis* (Engelm.) *Caryopitys Edulis* Colo. Bulletin 100.)

(Plate V. b. d.)

This is the pine from which the pinon nuts sold by fruit venders in cities are obtained. The tree is of small or medium size, with compact, pyramidal or rounded head. It occurs scattered or in open forests among the eastern and western foothills of Colorado, in southwestern Wyoming and western Texas and Arizona. It is not a tree of the high altitudes. The short, stiff leaves are in bundles of two and about one inch in length. The short, broad cones equal the leaves in length and are composed of few scales. The seeds are the largest of those of any other pine in this region. They are about the size of field beans and are wingless when separated from the scales of the cones.

This tree is useful mainly for its edible seeds, although the wood is sometimes made into lumber. It is quite extensively used for fuel and the manufacture of charcoal.

The pinon pine is adapted to growing in dry situations and for this reason may be planted where moisture is lacking. Its low, stocky growth adapts it for planting where a low mass of evergreen foliage is desired. The seeds germinate readily and this tree may be quite readily grown in this way. The seedlings may be transplanted at two years of age to encourage a compact root development.

GENUS *Picea*—THE SPRUCES.

The spruces are tall growing trees with conical or pyramidal form and tapering trunks. The needles are single, which distinguishes these trees from the pines, four angled and sharp tipped. At the base a short stalk-like portion is jointed to the green part of the needle and remains on the branchlet after the upper part of the needle has fallen. This makes the branchlets from which the leaves have fallen very rough and readily serves to distinguish the spruces from the firs.

The bark of the older limbs and trunks is usually dark grayish or reddish brown and consists of thin scales. The cones are hanging or pendulous when ripening and occur in the uppermost parts of the tree. They consist of thin scales each bearing two winged seeds. The seeds mature in the autumn of the first year. They are mostly small, pointed at the base and furnished with long, thin wings.

The spruces furnish some of our most ornamental evergreen trees, besides which they are useful in forming hedges, windbreaks and shelter belts.

KEY TO THE COLORADO SPECIES OF *Picea*.

A. Needles very stiff and sharp pointed, surface of twigs among the needles entirely glabrous or free from hairyness; cones 5-7.5 c. m. (2-3 in.) long.
1. *Picea Parryana.*

B. Needles less rigid and sharply pointed, surface of the twigs among the needles finely pubescent or hairy; cones about 4 c. m. (1⅝ in.) long.
2. *Picea Engelmanni.*

BLUE SPRUCE, COLORADO BLUE SPRUCE, SILVER SPRUCE.

(*Picea Parryana* (Andree) Sarg.)

(Plates VI. d., VIII., IX. b.)

This is one of the most admired and widely known evergreens and is certainly the handsomest of the spruces when well grown. It is somewhat limited in range, being found in Colorado and eastern Utah and northward into Wyoming. It commonly grows in small groups or groves along the streams in the mountain valleys and parks. It usually reaches a height of seventy-five to one hundred feet, occasionally taller, with a trunk one to two feet in diameter. The leaves vary in color from bright green to silvery greenish blue—the new growth being more distinctly bluish or silvery than the older foliage. Young trees are often very symmetrical and beautiful. When old the tree may become somewhat ragged and open and the color of the foliage may lose a degree of its blueness.

The bark is broken into rather small, oblong scales and on old trunks becomes thick and furrowed or grooved lengthwise. This character helps to distinguish the blue from the Engelmann spruce, the latter having the bark broken into rounded plate-like scales even on old trunks.

The cones consist of numerous thin scales narrowed toward the tips. They are usually prominent objects, as they hang in clusters in the upper part of the tree.

The wood is soft, light and weak and is sometimes used for lumber and fuel.

The blue spruce is largely planted for oranment and when well grown forms most beautiful specimen trees. For this purpose the bluest specimens are selected by the nurserymen, as the price which they bring is high in proportion to the blueness. This tree is well adapted to the formation of hedges and when well tended may be made impassible even to the smaller animals.

The blue spruce may be grown from seeds, gathered preferably from the bluest specimens, or native seedlings may be dug from the mountains where they occur. If wanted for specimen trees only the bluest should be saved, although the greener plants are equally useful for hedges and windbreaks. The finest specimens are usually obtainable through reliable nurserymen who grow them in large numbers, the best ones being propagated by grafting.

The blue spruce is at its best only when grown in a moist soil and under conditions of cultivation. When clothed in the new growth of the season such trees have the appearance of being frosted with pale blue, at which season they are unexcelled in beauty among trees.

THE ENGELMAN SPRUCE.

(*Picea Engelmanni* (Parry) Engelm.)

(Plates VI. a. c., IX. a.)

The Engelmann spruce is frequently confused with the blue spruce, which it often greatly resembles. It is a much larger tree than the blue spruce, in its northern range often growing to a height of 150 feet with a trunk four to five feet in diameter. Old trees are apt to be less regular in form than the blue spruce and the color is seldom so blue as the latter. The needles are less rigid and sharp than those of the blue spruce, so that an experienced nurseryman can usually distinguish the two by grasping the foliage with the bare hand. The leaves, furthermore, possess a disagreeable odor when bruised.

The surface of young twigs, under a hand lens, appears fuzzy or short hairy. This can be distinguished even by the naked eye if the twig is held up so that its outline is seen against the sky. The bark of large trunks is seldom grooved or furrowed as in the blue spruce, but is broken into rounded, plate-like scales of a reddish brown color.

The cones of the Engelmann spruce are seldom over one and a half inches long and the scales are often more rounded than those of the blue spruce.

The Engelmann spruce reaches the highest levels of tree growth and at timber line forms distorted spreading mats of scrubby growth. It is the most abundant of spruces in Colorado and forms extensive forests on the upper slopes and along the mountain streams. In its range it extends in general southward from the mountains of British Columbia through the interior mountain ranges of the continent to northern New Mexico and Arizona. It reaches its greatest beauty and size north of the United States boundary.

The bark is sometimes used for tanning leather. The wood is light and soft and is extensively manufactured into lumber, railway ties and to some extent is used for poles. It is probably our most valuable timber tree. The Engelmann spruce is not often planted for ornament, but is well adapted to such use in this state.

GENUS *Pseudotsuga*—DOUGLASS SPRUCE.

The members of this genus are tall, stately evergreens with much the same form as the spruces. They are nearly intermediate in some characters between the true spruces and the firs. The needles are single on the branchlets and are contracted at the base into a short stalk. They are soft, flattened, blunt at the tips and possess a prominent midrib in the form of a narrow ridge on the lower side. When the needles fall they leave small rounded scars on slightly raised portions of the branch. In these respects the Douglass spruces resemble the true firs. The cones, however, are in most respects like those of the spruces in that they are pendulous or hanging and that they remain entire when mature. The cones are readily recognized from those of the spruces, as well as other members of the pine family, by their feathered appearance, due to the presence of slender-toothed bracts that project from between the scales. This character is so prominent that these trees can be recognized as far as the details of the cones are visible.

Only two species in this genus are known in North America, one of which occurs in Colorado.

DOUGLASS SPRUCE, DOUGLASS FIR, RED FIR.

(*Pseudotsuga mucronata* (Raf.) Sudw.)

(Plates VI. b. e., IX. c., 5.)

The Douglass spruce is known by a number of common names throughout its range. It occurs among the hills and mountains of the greater portion of the Northwest, extending from British Columbia and Alberta on the north to northern Mexico and Texas on the south. It is a tree of conical form when young. It reaches its greatest size in the moist climate near the coast of Washington and Oregon and in the western foothills of the Cascade mountains, where it reaches a height of 200 feet or more with a trunk sometimes 10 to 12 feet in diameter. In the drier inland regions it is usually less

than one hundred feet tall and two or three feet through. The bark remains comparatively thin and smooth for a number of years, but on old trunks becomes thick and deeply cracked and furrowed into gray, coarsely broken ridges. The wood is light red or yellowish in color and variable in density and quality. It is largely manufactured into lumber in its northwestern range, and is extensively employed in construction work, railway ties, piles, and for fuel. Two varieties of this tree, the red and the yellow fir, are distinguished by lumbermen. The former of these is coarse grained and dark colored and is not considered so valuable as the latter. The bark is occasionally used in tanning.

The Douglass spruce is planted quite extensively as an ornamental tree in the eastern United States, and numerous forms or varieties are in cultivation. It is a tree of rapid growth, especially when planted in a moist soil. It has not made as healthy a growth on the Agricultural College grounds at this station as the blue spruce. It is readily grown from seeds, which are of fair size. This evergreen may be recommended for planting in the windbreak and for specimen trees on the lawn.

GENUS *Abies*—THE FIRS, BALSAMS.

The firs are tall growing, conical trees quite similar in appearance to the spruces. They are fond of the higher altitudes where the cold air and the moisture of frequent storms bring them to their greatest perfection. The leaves, like those of the spruces, are simple and grow from all sides of the branchlets. Those on the lower sides of the twigs, however, turn upward in such a way as to form flattened masses of foliage. The branches arise in whorls from the sides of the main trunk so that when viewed from the side such trees appear in the form of circular terraces of foliage disposed with beautiful regularity.

The needles are flattened, usually grooved above and slightly notched at the tip. The cones occur only in the topmost parts of the trees and stand erect on the upper side of the branches. They are mostly purplish or blackish in color, with thin, closely crowded scales. When mature the cones break up by the falling away of the scales, so that complete cones of the firs are never found beneath the tree.

The bark on young trees is smooth, but becomes roughened and broken on old trunks. The wood is mostly soft and brittle and is not prized by the lumbermen.

The name Balsam, which is often applied to the trees of this genus, is suggested by the presence of balsam or resin vesicles in the bark.

The balsam fir of the northeastern states and Canada *(Abies balsamea)* possesses balsam-containing blisters in the bark from which the substance known in commerce as "Canada Balsam" is obtained.

KEY TO THE COLORADO SPECIES OF *Abies*.

A. Leaves of vigorous lower branches 2.5-4.5 c. m. (1-1¾ in.) long; the two resin tubes, as seen in cross section under hand lens, deeply imbedded within the leaf tissue. Cones purple or nearly black.

1. *Abies lasiocarpa*.

B. Leaves of vigorous lower branches 4.5-7.5 c. m. (1¾-3 in.) long. The two resin tubes close to the lower surface. Cones green, yellow or purple.

2. *Abies concolor.*

BALSAM FIR, ALPINE FIR.

(*Abies lasiocarpa.* Nutt.)

(Plate VII.)

This tree is distributed throughout the mountainous parts of western North America. In Colorado it frequents the high mountain slopes and summits. It is a medium sized tree seldom over 100 feet tall, in this state, and two feet in diameter.

The leaves on the cone-bearing branches are usually short, stiff, and curved upward and tipped with sharp points. The cones are frequently almost black in color and are usually smeared with pitch. The bark on young trunks is quite smooth with numerous transverse scars, but on old trunks becomes cracked and scaly.

The wood of this tree is considered of little value by the lumbermen, as it lacks strength and durability and is adapted only for the coarsest quality of lumber. It is used for fuel to some extent. The writer found, in the cutting of timber from one forest reserve, that this fir was being removed to make room for the more valuable Engelmann spruce with which it was growing. This fir is planted to some extent as an ornamental tree in the northern United States and Europe.

WHITE FIR.

(*Abies concolor,* Lindl.)

The white fir, with its regular whorls of frond-like foliage masses, is a very handsome tree. During the first year or two the leaves are similar in color to those of a good specimen of the silver spruce, which it often rivals in beauty. It is a much larger tree when fully grown than the preceding species. It is the only fir within the arid regions of the Great Basin and of southern New Mexico and Arizona. In Colorado the white fir is found only in the southern half of the state extending to the Pike's Peak region. Some handsome specimens of moderate size are to be seen in North Cheyenne Canon, near Colorado Springs. The leaves are considerably longer than those of the balsam fir and the cones are larger and usually lighter in color. The wood, while coarse grained and not strong nor durable, is sometimes used for lumber of which packing cases are made. The tree is planted to some extent for ornament and is worthy a trial, as well grown specimens are pleasing in form and color and may serve to introduce variety in the evergreen plantings in parks and about the house.

Juniperaceae—JUNIPER FAMILY.

The members of the juniper family are distinguished from those of the pine family principally by the fruit. Thus, instead of forming a dry cone composed of woody or parchment-like scales, the junipers possess a berry-like fruit, in the pulp of which the seeds are imbedded. These berries, however, were at first much like the very young cones of the pine family. The scales of which they are composed are enlarged at the outer end and are comparatively few in number. After the ovules are fertilized by pollen from the staminate flowers, which in the junipers occur on distinct trees, the scales grow together and form the so-called juniper

berry. On close examination, marks indicating where the scales were located can be easily seen.

The seeds of the junipers are furnished with hard, bony coatings which enable them to pass unharmed through the alimentary canal of birds, which sometimes feed upon them, and in this way distribute them to new locations.

The junipers are strongly aromatic and from some species volatile oils are obtained which are used in medicine and in the manufacture of perfumes.

The wood of the juniper is close grained, not hard, but durable. Most of the species of junipers which occur in this state are low, spreading, shrubby plants which are not adapted to the production of lumber. These low-growing sorts, however, are well suited for planting in the shrubbery border, on exposed banks and to cover the tops of walled terraces and rockwork.

Two genera of the juniper family are represented in Colorado, but only three species commonly reach the stature of small trees.

KEY TO THE COLORADO GENERA OF THE JUNIPER FAMILY.

A. Leaves in whorls of three, on mature branches, awl-shaped, spreading, 10-12 m m. (3/8-1/2 in.) long, channelled and whitened above, convex and green below. Buds scaly.

Genus Juniperus.

B. Leaves opposite in pairs, on mature branches, scale-like and flattened against the branchlets to which they are usually grown fast; about 2-3 m m. (1/8 in.) long. On young trees and vigorous shoots the leaves are usually longer, slenderly pointed and somewhat spreading. Buds naked.

Genus Sabina.

GENUS *Juniperus*—THE JUNIPERS.

(Plate VIII. 2.)

The species of junipers which occur in Colorado frequent the rocky hills and exposed mountain slopes. They are distinguished from the red cedars or savins principally by the leaves being comparatively long and joined to the branch much like those of the spruces. The berry-like fruit of the junipers is borne close against the side of the branch, while that of the red cedar is on the end of a very short branch.

Two species of the genus are known in this state. The first of these, the mountain or low juniper *(Juniperus sibirica)* (Plate VIII. 2) is a low spreading shrub common in the foothills and rocky places in the mountains. Its leaves are abruptly bent at the base and are deeply grooved on the upper surface.

This shrub is worthy a place in the shrubbery border and from

its hardy, drought-resisting character may be used where moisture is not plentiful

The common juniper *(Juniperus communis)* sometimes reaches a considerable size, especially in its eastern range. In its low form it is scarcely distinguishable from the former species, but is apt to be more erect and with straight, nearly flat leaves with tapering points.

The distilled liquor commonly known as gin owes its flavor to the use of juniper berries in its manufacture.

The common juniper is adapted to forming low hedges, as it endures clipping well.

GENUS *Sabina*—RED CEDARS, SAVINS, JUNIPERS.

(Plate VIII. 1.)

The common red cedar is the type of tree of the present genus. The foliage consists usually of two somewhat distinct forms of leaves. Those on the main branchlets are frequently one-fourth to three-eighths inches long on vigorously growing trees, with the pointed tips free and somewhat spreading. On the smaller lateral branchlets the leaves are usually less than one-eighth inch in length, are scale-shaped and broadly pointed. Both forms of leaves adhere closely to the branchlets on which they grow so that the younger stems are entirely covered by the leaves. After one or two years the longer leaves die and turn brown, but do not entirely disappear until the branch is several years older.

The oldest leaves are shed in spring of each year at the beginning of the growing season, but instead of falling singly as in the junipers, the small lateral branchlets drop off, carrying with them the closely adhering scale-leaves.

The heart wood of the red cedars is soft but fine grained and very durable and possesses a pleasing fragrance which is retained almost indefinitely. The wood has been extensively employed in the manufacture of water pails and wooden ware, for interior finish and for cabinets and chests for protecting furs and woolens against the ravages of moths. It is the principal wood used in the manufacture of lead pencils and is probably the only wood sold by the pound. The rapidly diminishing supply for this purpose is being felt by the manufacturers of pencils, who are beginning to consider possible substitutes.

The oil of red cedar, distilled from the leaves and wood, is used to some extent as a perfume, as it imparts the characteristic odor of the wood to cheaper woods.

The berries ripen in the autumn of the season they were produced.

Of the four species of red cedars known in Colorado three are sometimes trees of small or medium size. The characters which separate them are not easily recognized except by botanists.

The Utah red cedar (Sabina utahensis) is a bushy tree seldom more than twenty feet high, which occurs in the desert region between the Rocky and Sierra Nevada Mountains. It is found in the western parts of this state on dry mountain slopes and tablelands. It is locally used for fuel and fencing and the fruit, which is a rather dry, sweet berry, is used for food by the Indians, either fresh or ground and baked into cakes.

The single-seeded red cedar (Sabina monosperma) occasionally reaches a stature of forty to fifty feet in favorable locations. It occurs along the eastern base of the Rocky Mountains in the southern half of Colorado and extends to western Texas, over the mountain ranges of Nevada and into Mexico. It is often associated in southern Colorado and Utah with the pinon pine.

It is usually an irregular, open-headed tree, with red-brown bark on the naked branchlets and thin, grayish, scaly or shreddy bark on the trunks. The fruit is about one-eighth to one-fourth inch long, black with a whitish bloom and contains usually one or rarely two or three grooved seeds. The wood and fruit of this species are used for the same purposes as in the preceding species.

The Rocky Mountain Red Cedar (Sabina scopulorum) (Plate VIII 1.) is widely distributed throughout the northwestern portions of the United States, from the eastern foothills of the Rocky Mountains to the coast of British Columbia and Washington, and from Alberta to western Texas and northern Arizona. It frequents the foothills and river bluffs and is our common red cedar in most parts of Colorado. It reaches a height of thirty to forty feet, when favorably situated, and forms an irregular round topped head.

The berries are bluish black with a bloom and contain one or two bony-shelled, grooved seeds. The fruit is usually somewhat larger than that of the preceding species and ripens at the end of the second season.

The red cedars, on account of their very fine foliage and branchlets, may be effectively used among other evergreens to give variety to the planting. Their foliage is usually somewhat grayish in winter. Although of slow growth their hardiness and the fact that they bear pruning well fits the red cedars for use in forming hedges and windbreaks.

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The Agricultural Experiment Station

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Arsenical Poisoning of Fruit Trees

BY

WM. P. HEADDEN

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ARSENICAL POISONING OF FRUIT TREES.

WM. P. HEADDEN.

I was called upon at one time to investigate the cause of the death of some shade and ornamental trees, and the bad condition of the property in general. The claim was advanced that arsenic and lead were the cause, more particularly the former. The assertion was made that animals had died as the result of feeding upon the grass growing on the premises. Examination of the grass, the bark of the trees, the soil, and the dust which had collected in unused portions of the buildings, all showed an abundance of arsenic, lead and copper.

In connection with the preceding facts, the probable cause of the death of the trees seemed apparent and yet certain considerations led me to be cautious in insisting upon the arsenic present as the cause. For instance, calcic arsenite was at that time being used on our fruit trees to destroy the codling moth—the whole tree from the outermost twigs to the very base of the trunk was, I well knew, literally bathed with this arsenical preparation several times in the course of a season. The whole of this arsenic sooner or later found its way to the soil. I had not, at that time, proved by direct experiment, nor learned that any one claimed that the fruit trees had been injured by this arsenic. This seemed to me so strong an argument against the too ready assumption that arsenic was really the cause of the death of the trees, that I felt obligated to caution the attorneys that it was not clear to my mind, that neglect had not contributed more to the condition of the property than the causes complained of. Still the facts were well established, i. e., the trees were dead and arsenic was present, also lead and copper, and in spite of the fact that our apple and pear trees were being sprayed, a number of times annually with arsenical preparations and no injury reported, except in cases where the arsenic had been applied in a soluble form, I was quite fully convinced, that the arsenic had contributed largely to the death of the vegetation on this property.

The protection against arsenical poisoning in the case of our orchard trees is the insolubility of the arsenical preparations used in spraying and further that these preparations shall not be changed or become soluble in the soil. In the case referred to, it would have been judged that the iron and especially the lime present, both as carbonate and sulfate, was sufficient not only to render the arsenic insoluble but also to prevent its being brought into solution again, still it was my opinion that the arsenic was really the principal cause in the destruction of the vegetation in question.

While the conditions met with in the case of this property were not identical with those obtaining in orchard culture, they had enough in common with them to convince me that there were but two conclusions to draw, either that I was in error in regard to the agency of the arsenic in this case, or that there would come a time, and that soon, when the arsenic applied would eventually find its way into the soil, and prove a source of danger to the trees. I was, at that time, going on four years ago, so fully convinced that the arsenic would become a source of grave danger, that I ventured to express this veiw to the orchardists of the State and cautioned them that the probability of injury from this cause was imminent.

Prof. Gillette, who, as an Entomologist, is interested in the control of insects injurious to the fruit crops of the State, has repeatedly suggested that I should take up this line of investigation, Prof. Paddock, also, who, as a Horticulturist, is interested in the diseases of the trees—has made the same suggestion. These statements are not made to devolve any responsibility upon these profes sors but to show that this view has not been hidden from the people or my colleagues and the presentation of this bulletin is not a hasty resolve or a thing done without a very keen appreciation of its importance not only to the orchardists of Colorado but to all orchardists.

I will add before leaving these introductory paragraphs, that this work in my Department is directly an outgrowth of my attempts to study the alkalies of this State, but I deem it both just to the interests of the State and wise to segregate it, and present it at the earliest advisable time, irrespective of the rest of the work.

It will appear in the proper place how the injuries herein described and explained are influenced by the alkali, indeed, the orchardists themselves have repeatedly suggested this by such questions as: Has our strongly alkali water any effect on our spray material, specifically upon the lead arsenate?

While the suggestions of danger were made so long as three years ago, no observations of any trouble were officially made public until January 1907, when Mr. O. B. Whipple in his report as Field Horticulturist of the Western Slope Fruit Investigation, calls attention to certain difficulties under the title of Root Rots. I give the whole of his report touching upon this subject taken from Bulletin 118 of this Station:

ROOT ROTS.

"Two apparently distinct forms of root rot are found. One form, which is proving the least destructive of the two, seems to show no preference for varieties, and confines itself to that part of the tree below the ground. The other seems to work exclusively on the Ben Davis and Gano, and the trunk as well as the roots are affected. The disease often extends upward into the large branches. The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out

in sharp contrast to the healthy tissue. The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foliage drops early. This early ripening of the foliage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. (See Plate I., lower figure). Trees showing an early bronzing of the foliage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit, and dies in mid-summer, the fruit and leaves clinging. (See Plate I., upper figure). The disease seems to be infectious, as the trees appear in groups, and in many cases it appears as though it were carried by water. When a diseased tree is found, several more are generally found in the same row. However, other varieties besides the Ben Davis and Gano may stand in the same row with diseased trees on either side and show no sign of contracting the disease. The fact that Ben Davis and Gano are very tender as regards the application of arsenical sprays has suggested to my mind that the trouble may be due to arsenic collecting about the crown of the tree and killing the bark. However, the fact that trees sprayed with arsenate of lead and arsenite of lime are alike affected, seems to be cntrary to such a hypothesis.

"Prompt removal of the trees affected seems at present to be the only treatment that can be suggested. Reports indicate that the disease has only been in the orchards two or three years at the most. Soil conditions seem to have no relation to the disease, as it is found on all kinds of soils."

The description of the affected trees as given by Mr. Whipple is, I believe, entirely reliable as he has been in this field for several years, and has had opportunity to observe these trees at all stages of the affection. I can, in fact, corroborate his statements as Mr. Whipple was kind enough last Autumn and again this spring to point out a number of these trees at different stages in the process of dying. While the appearance of brown spots on the trunk of the tree are observable early in the progress of this trouble, they are not the seat of the trouble, which beginning on the crown of the tree has by this time advanced to the trunk. Whether it ever begins on the roots below the crown is not at present known. It is not to be wondered at that Mr. Whipple, without a definite knowledge of the cause of the trouble, states that the disease seems to be infectious. He pointed out to me a row of Ben Davis trees, four of which were already dead, with leaves and fruit still clinging to them. In the adjoining row was another tree which was likewise dying, as I now recall it—this tree stood at a point where the irrigation water crossed from the row of four dead Ben Davis trees and passed close to this one, seemingly justifying Mr. Whipple's inference that the disease is infectious and also the further statement, "and in many cases it appears as though it were carried by water." My explanation of this is a different one as will appear in a future paragraph.

Mr. Whipple in the next sentence, calls attention to an important fact, i. e.—that the two varieties, Ben Davis and Gano, are very sensitive to arsenical sprays, and suggests the possibility that the trouble may be due to arsenical poisoning, but seems to dismiss this as an untenable hypothesis. Another point in Mr.

Whipple's very brief account of this disease is that the disease had been noticed for only two or three years. Information which he and I have since gathered corroborates this statement; the earliest observation of the affection of the trees of which we were able to learn was in 1904 and trees have been dying in certain orchards annually since that date.

VARIETIES AFFECTED.

The varieties affected in this way are by no means confined to the Ben Davis and Gano. The following varieties are also affected: Spitzenberg, Early Harvest, Wolf River, Lawver, Blacktwig, Baldwin, Jonathan, Grimes Golden, and Pewaukee, and without doubt, other varieties might be added if search were made to find every variety affected in this way. The trouble also extends to pear trees, but I have studied apple trees mostly.

AREA INVOLVED.

At this writing I am not prepared to give any territorial limits to the trouble. I have observed it from near Fruita almost to Palisade and in the neighborhood of Delta. I am further credibly informed that the same condition of the trees has been met with in the neighborhood of Canon City. If this latter statement is correct, our principal orchard growing sections are involved and the importance of definitely establishing the cause and if possible, a correction for the trouble, becomes very great.

THE NUMBER OF TREES AFFECTED.

This would be very difficult to determine and I have no data on which to base even a rough estimate, but an idea may be obtained from the following facts. One man stated that in the last few years, he had lost 50 per cent of his Ben Davis. Another stated that he began pulling up a few trees four years ago and this year he had removed nine trees and there were others which he should have removed; another man had removed twelve and still another the same number. The four Ben Davis trees in the row that I saw last October, together with others had been removed this Spring and there were still other trees in this orchard which were affected. I visited one orchard in which there was a large number of affected trees—in other orchards, there are only a few. The total number of affected trees in the orchards of the Western Slope, is already unfortunately large.

THE PROBABLE CAUSE OF THE TROUBLE.

I have already clearly indicated my conviction that the cause of the trouble is arsenical poisoning; that there are some trees suffering from other causes is quite certain but the cause of the greater

portion of the trouble is the arsenic which has accumulated in the soil. The expression of this conviction is not a hasty one, for I am fully alive to how much it means to this state and all other orchard growing states where similar soil conditions prevail, but it is for the best interests of orchardists that they should know the facts pertaining to the death of their trees and the conditions of their soil.

THE ACCUMULATION OF ARSENIC IN THE SOIL.

The spray material used in combating the codling moth is either a calcic arsenite or lead arsenate. The number of sprayings applied vary from two or three to nine during the season. I do not think that this Station has ever recommended more than three sprayings during the season, but many orchardists apply more. The amount of lead arsenate used is from four to six pounds to each 100 gallons of water. The average orchardist does not consider the amount of arsenic thus applied to a single tree a very large quantity, and he cannot be expected to consider the nature and possibilities of the material that he is applying, so in many cases he applies, as he thinks, wisely, a liberal quantity, sometimes using eight to ten pounds of lead arsenate to 100 gallons of water, and applies eight or ten gallons of the turbid liquid to the tree. If six pounds of pasty lead arsenate be used to 100 gallons of water and ten gallons of the mixture be applied to a tree we have six-tenths of a pound of the pasty arsenate, or in round numbers, three-tenths of a pound of dry lead arsenate.

Practically the whole of this eventually finds its way into the soil. If this be repeated three times during a season we have 1.8 pounds of pasty lead arsenate or 0.9 pounds of dry arsenate applied to each tree, or considering that the dry lead arsenate contains 25 per cent of arsenic acid, we have 0.225 pound of this substance per tree and allowing 80 trees to the acre, we have 18 pounds of arsenic acid to each acre of the orchard. If this amount of arsenic acid were evenly distributed through the first foot of soil, it would correspond to four and a half pounds of arsenic acid for each million pounds of soil, or 4 1-2 parts per million. This arsenic is, however, not evenly, but very unevenly distributed, as the spray mixture runs down the trunk of the tree and accumulates in the soil at its base. It is not done one year only, but every year, unless there should be no fruit. Some of our orchards have already been sprayed for eight or ten years and a few of them for even a longer period, so that we would expect to find a considerable accumulation of arsenic in the soil, especially in the soil at the base of the trees. This corresponds to the facts as found by analysis. In one sample taken beneath the head of a twelve-year-old apple tree, and representing the soil to the depth of five inches, I found arsenic corresponding to 30.6 parts of arsenic acid to each million parts of the soil; in

another, soil 25.5 parts; in another 26.0 parts; in another 38.2 and in still another, 61.3 parts per million. The sample giving 38.2 parts arsenic acid per million was taken at the base of the tree and to a depth of one foot, the last sample, giving 61.3 parts arsenic acid per million, was taken at the base of the tree and to the depth of four inches. All of the samples were taken either in the Spring of the year or at least some time after the last spraying, so that they ought to fairly represent the orchard soils. We find in fact, what was from the beginning patent, namely that the arsenic does accumulate and is already present in our orchards in dangerous quantities, if it, by any means, should become soluble.

THE ARSENIC IS TAKEN UP BY THE TREES.

It is altogether correct that the spray material applied is a compound of arsenic either difficulty soluble or insoluble in water as calcic arsenite or lead arsenate. It is also true that literally hundreds of trees have already died or are sick, as I believe, beyond hope of recovery. The symptoms are the same. The duration of the tree after showing the first early ripening of its foilage is about one year; the attack of the disease is at the same point, and progresses in a uniform manner. Mr. Whipple describes its course as follows:

"The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out in sharp contrast to the healthy tissue."

"The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. (Plate II., Fig. 1). Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foilage drops early. This early ripening of the foilage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. Trees showing and early bronzing of foilage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit and dies in mid-summer, the fruit and leaves clinging."

I have seen no tree in which the trouble has advanced to that stage indicating its death during the following summer, but that some of the roots, in fact, most of them in nearly every case, had been attacked, the bark destroyed to a greater or less extent, the woody tissue stained brown and the bark at the base of the trunk severely attacked just below the ground. It is from this point that the trouble seems to take its start. Some facts, however, particularly the condition of some of the roots, they being entirely dead, while others standing in just as close a connection with the diseased crown are in much better condition, suggest that the attack may not be confined to the crown. The condition of the crown produced by this trouble is shown in Plate II., Fig. 2, also the stained or discolored condition of the tissue. This is a photograph of a stump of a Ben Davis tree which was removed this spring, and would have died this summer. Plate III., Fig. 3 is that of another Ben Davis tree

from another orchard and shows how the woody tissue is stained. The notch shows where a portion of the stump was removed for the purpose of examination. This tree was in bloom when dug up. It was perfectly representative of a number of other trees in the same orchard which had already been dug up or had been marked for removal. Many trees in this immediate neighborhood are affected in the same manner. The trouble is not confined to one orchard. In this case we found it in four, we might say, contiguous orchards. I have taken portions of at least 14 different trees. They were from a considerable variety of soils and were trees that had just been removed or which we removed ourselves, or are still standing in the respective orchards. So far as I could learn, only two of these trees failed to show some life this season and one of these was a pear tree which we dug up ourselves. This tree had been cut back severely in 1907 and had thrown out a few shoots, some of which had made a fair growth. None of them were trees which had died and remained standing and had had an opportunity to absorb arsenic as dead trees. As stated, some of the trees represented by our collection are still standing and were in full bloom at the time we removed the roots and branches. The condition of the roots and bark, however, was that produced by the long continued action of the poison.

The conditions found are as follows: The bark at the base of the trunk and just beneath the ground is destroyed and the damage extends up the trunk sometimes even into the limbs. (see plate II.) This damage is shown on the trunk by the bark being brown and sunken. On the roots, the bark is disintregated as is well shown by Plate IV., Fig 1, a sample taken and photographed by Mr. Whipple. Often, in the advanced stages of the trouble, the bark is almost charred and the wood itself is even blackened. The tissue is strongly attacked and yields to the rasp like wood charred sufficiently to destroy its fibre. It looks and acts like wood acted on by a dilute acid, sulfuric acid for instance, only the darkening is not, as a rule, so intense as would correspond to the same degree of disintegration by this acid.

The limbs and branches of trees affected in this way usually, but not invariably, present a case of "black heart." The interior portion of the branch is strongly discolored with a margin pronouncedly darker than the rest of the interior. (Plate IV., Fig. 2; also Plate III., Figs. 1 and 2). This condition is usually attributed to another cause, freezing at some time or other, but we have pretty direct proof that in these cases, it probably has been caused by the poisoning of the tree. It is a rule that branches of healthy trees show this difference to a very small extent, they being usually white from the center to the circumference. Even in Fort Collins, where we have severe changes in the temperature,

this seems to be the case. A branch from a neglected tree in my garden is white throughout (Plate IV., Fig. 4). The age of this tree is not less than 15 years, and has to my knowledge been subjected to temperatures ranging as low as -40 degrees F., and often below -18 degrees F. I do not know the early history of this tree, and do not wish to give more weight to the fact mentioned than is due. I have not examined pear trees as carefully as I have apple trees, but the few branches that I have observed were not discolored in this manner. Plate IV., Fig. 3 represents a section of the trunk of a pear tree, killed by arsenic, and shows the manner in which the wood is stained.

Another effect of this trouble is to cause the bark to split and the wound to bleed. (Plate V., Figs. 1 and 2). This result may be partly and possibly wholly induced by another cause. Mr. Whipple suggests that the splitting open of the bark may result from the girdling, but this will certainly not apply in many cases, though it may in some. I have in mind two orchards in which this cracking and bleeding occurs to such an extent that any person whether he were accustomed to orcharding or not would take notice of it. One of these orchards is today rated as a very fine one.

With these general statements concerning the manifestations of the difficulty, I will give the facts on which the statement rests, that the arsenic is not only in the soil but has been absorbed by the trees.

I have taken samples from fourteen trees, eleven apple and three pear trees. These samples consist of roots, stumps, one trunk and branches. I should add to the above two samples of the deposit formed by the bleeding referred to in a preceding paragraph. On these various samples, thirty tests for arsenic were made and its presence was established in every instance. I did not attempt to make quantitative determinations except in a few cases which showed from 1.25 parts to 12.77 parts of arsenic per million of the woody tissue. I found the reaction for arsenic stronger in the roots and crown of the trees than in the branches, but could not with certainty distinguish any difference in the amount of arsenic present in the green or natural colored portion of the limb and the discolored portion.

I do not wish to weary the general reader with technical details, but it is proper that he be assured that the arsenic reported as having been found in these thirty different samples, was not contained in any or all of the reagents used. The proof of this was obtained by using a piece of oak wood and carrying it through as though it were a sample of an apple tree when a negative result was obtained showing that both the wood and the reagents were free from arsenic. This was not the only precaution, for four blank tests were made during the work to make sure that no error should arise from

this source. The care taken was in all ways as circumspect, so far as the analytical work was concerned, as though the examination of human viscera were in my hands. Another source of error lay in the danger of getting some particles of spray material with the bark of the sample. This was obviated by removing the bark from both the roots and branches, before taking the sample for analysis.

In one case, that of a pear tree, the bark was examined; in this case the bark was smooth and sound enough to permit of its being washed with a stiff brush. It gave a fainter reaction for arsenic than the wood which it covered.

With these statements it may fully suffice if I give the details of only two samples a little more fully.

One taken from the trunk of a small pear tree ten years old. Section cut out 30 inches above the ground, bark entirely removed, wood quite generally stained but not deeply so like the roots or central portion of many of the branches of the apple trees. This section is shown in Plate IV., Fig. 3. The wood is hard but rasps easily. I took 60 grams, almost exactly two ounces, destroyed the wood by means of sulfuric and nitric acid; collected the arsenic as arsenate of Iron; dissolved in sulfuric acid and introduced it with proper precautions into an active Marsh apparatus and obtained arsenic corresponding to 2.55 parts of arsenic acid per million. Owing to unavoidable losses, the arsenic obtained is too low.

The second one is a sample of a stump. I cleaned it thoroughly by paring off all bark and soiled portions and rasping it. I took two ounces as before, proceeded in exactly the same manner and obtained arsenic corresponding to 12.77 parts of arsenic acid per million. Every sample was proceeded with in just as careful a manner as these two, and arsenic was easily proven to be present in the tissue of every sample, whether it was taken from the central, the intermediate or exterior portion of the root or limb.

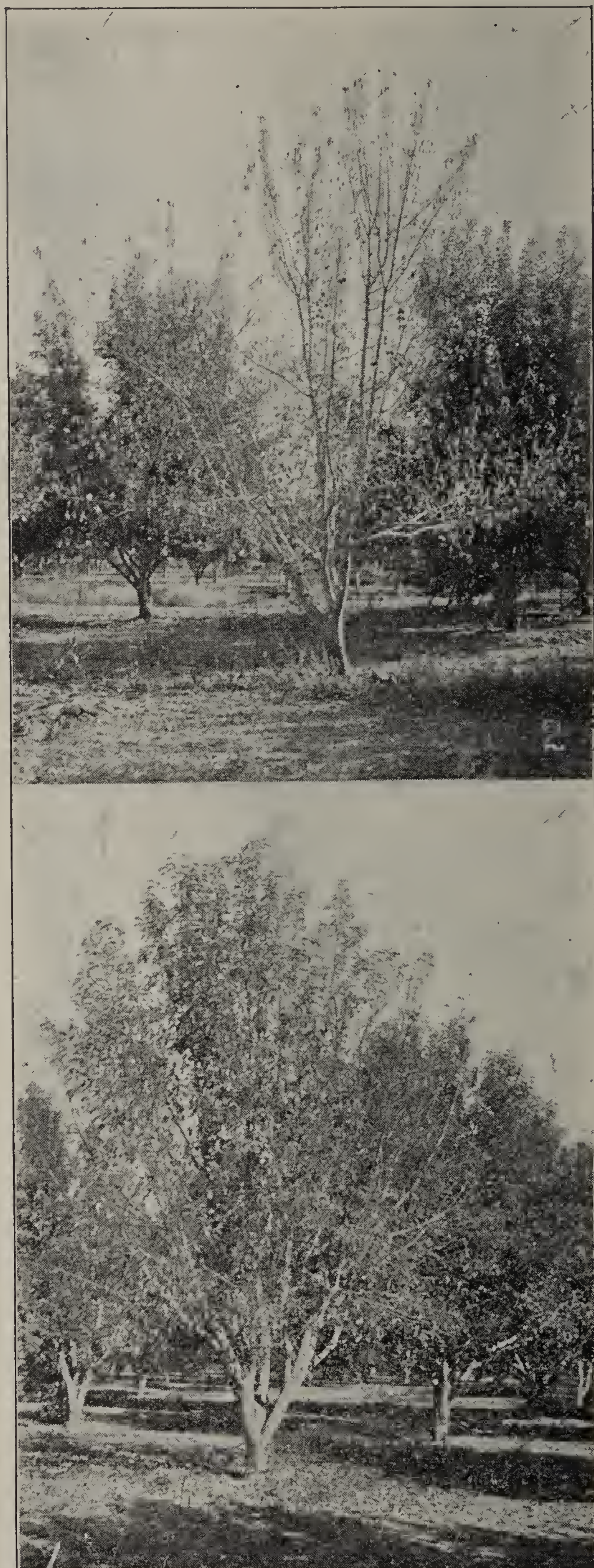
We have seen that the arsenic is accumulating in the soil, having already reached as large an amount as 61.33 parts of arsenic acid in a million of soil.

I have stated in Mr. Whipple's words, the manner in which the trees are affected and have given the description of what I myself found.

Further we have shown that in these dying trees arsenic is present in the roots, the trunk and branches varying up to 12.77 parts per million.

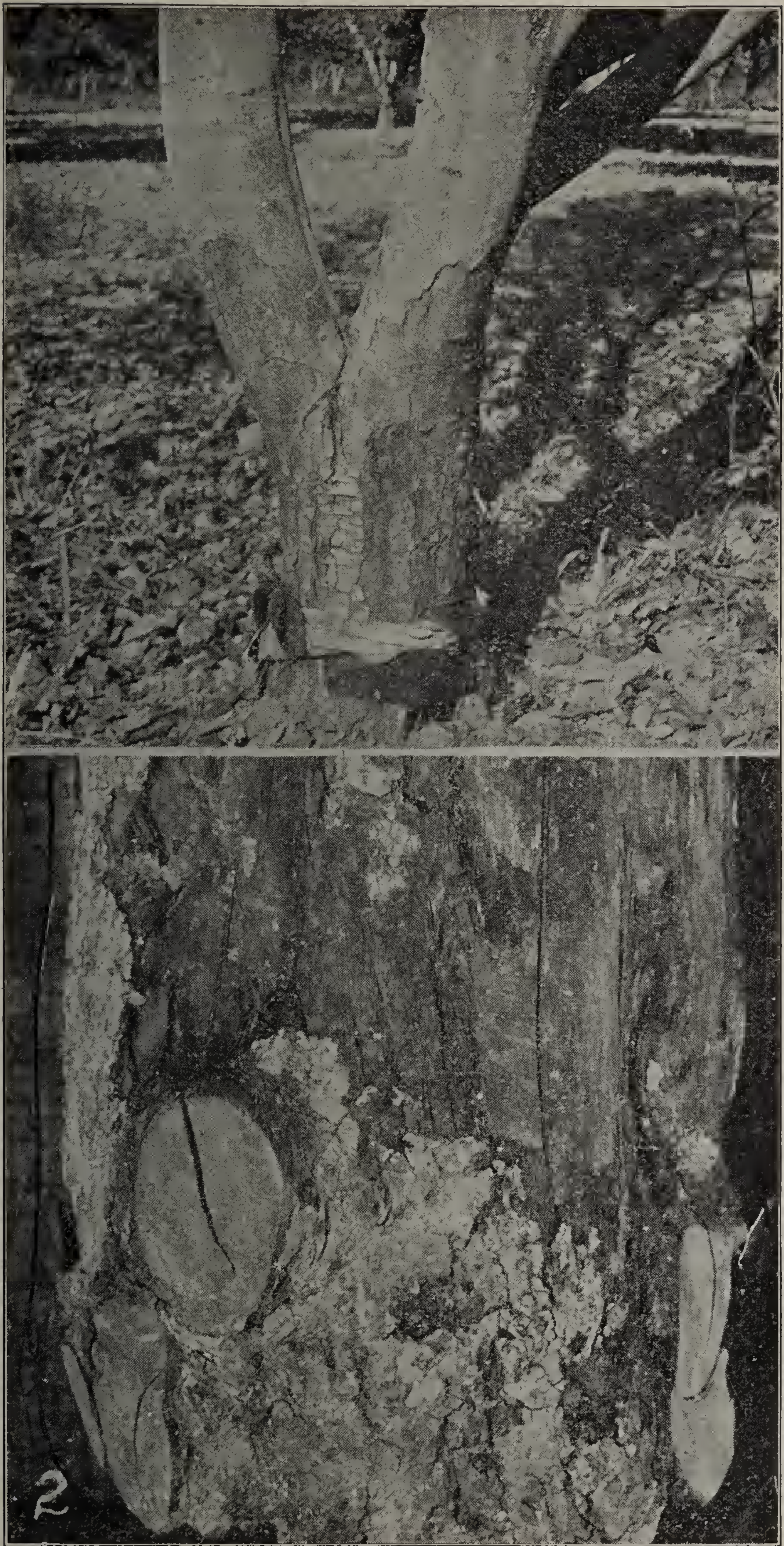
ARSENIC IS THE CAUSE OF DEATH.

So far the question, Is the arsenic really the cause of the corrosion of the bark beneath the ground, the killing of the bark on the trunk, the killing of the roots and the staining of the wood, in short is it the cause of death? has not been answered. I have stated



Colo. Ag. Expt. Sta.

PLATE 1.



Colo. Ag. Expt. Sta.

Plate 2

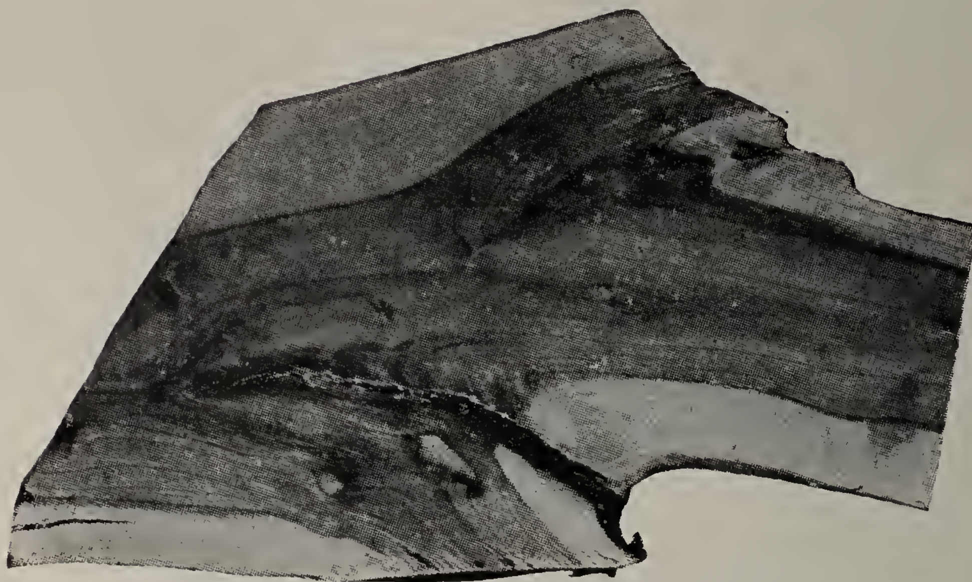


Fig. 2

Fig. 1

Colo. Ag. Expt. Sta. Fig. 3

Plate 3.

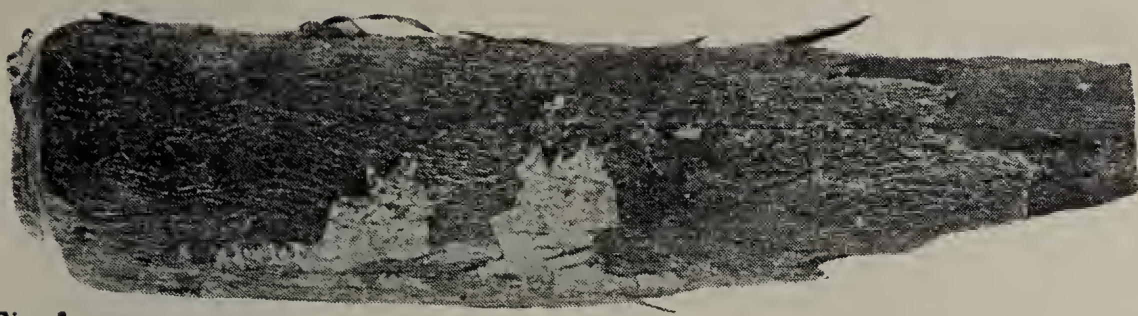


Fig. 1

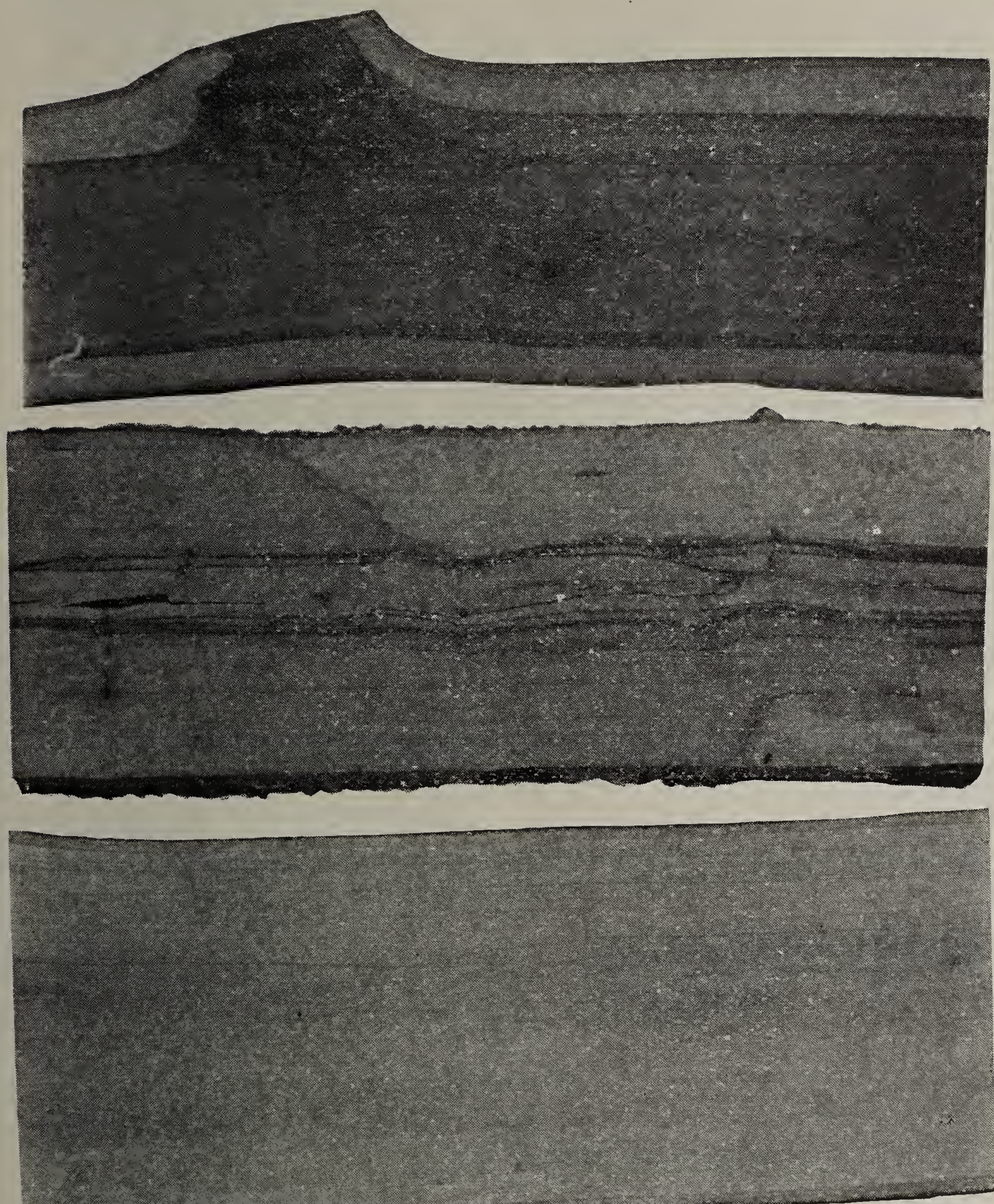


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Plate 4.

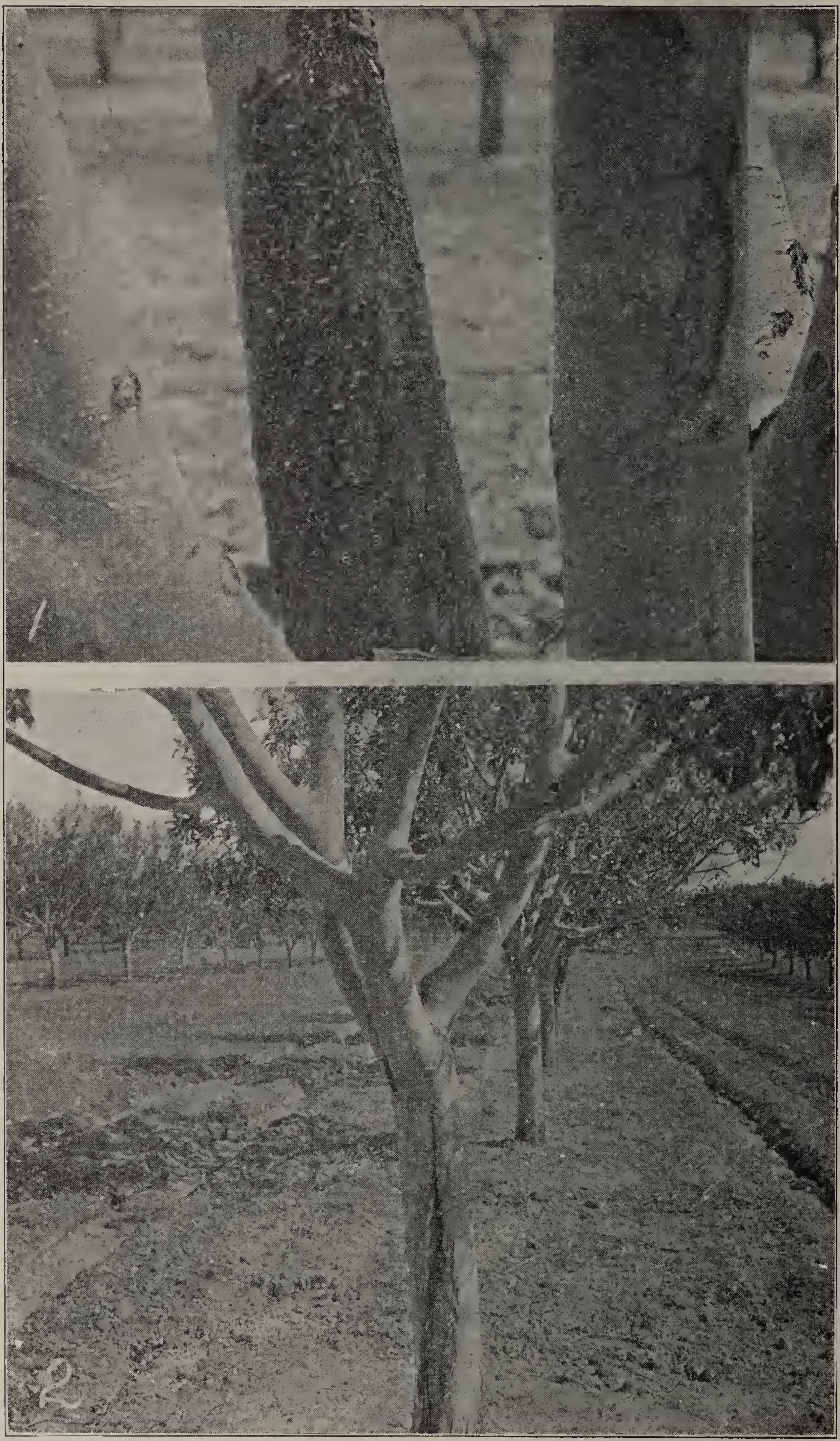

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PLATE 5.

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Plate 6.

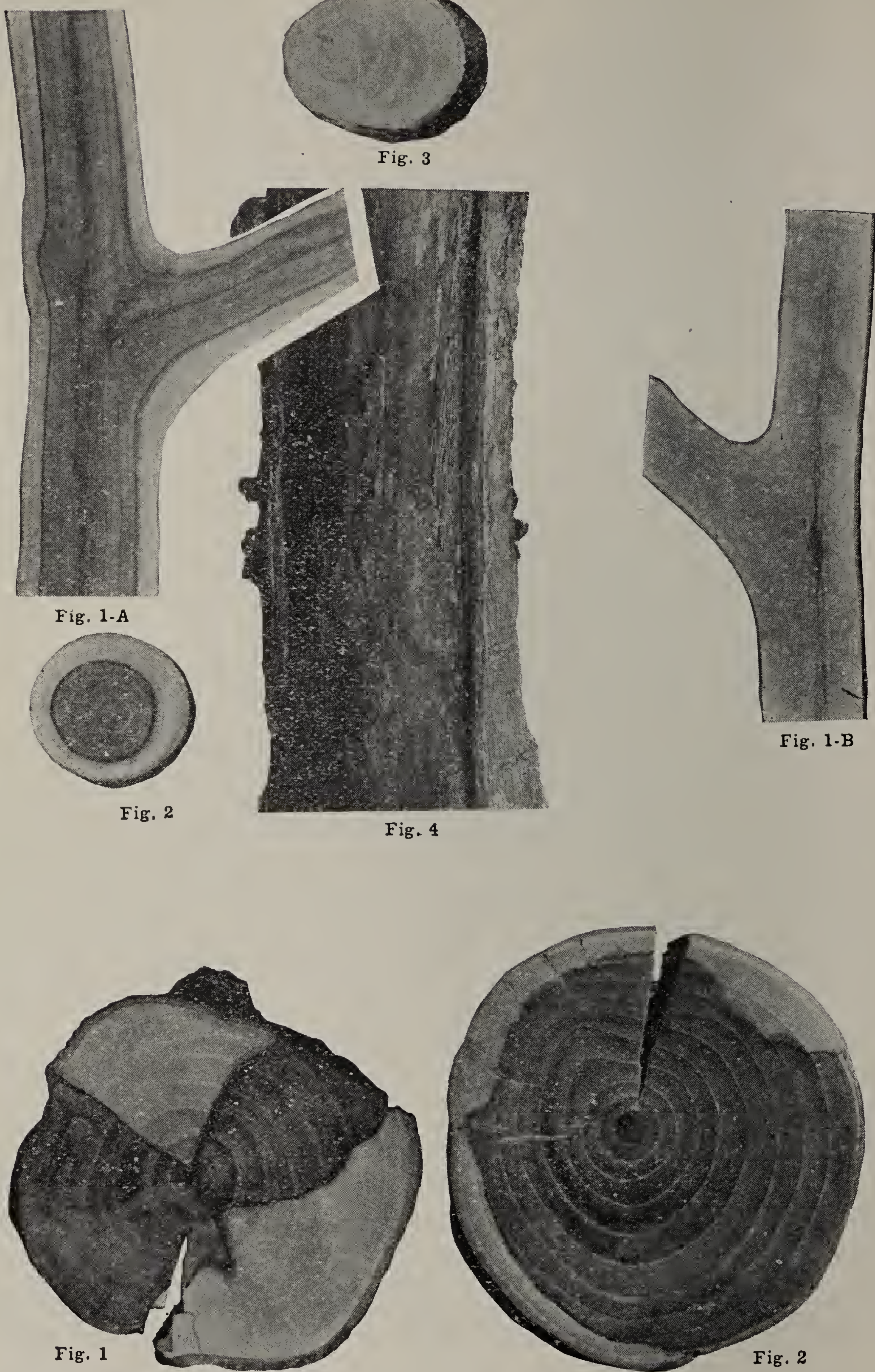

Fig. 3

Fig. 1-A

Fig. 1-B

Fig. 2

Fig. 4

Fig. 1

Fig. 2

Colo. Ag. Expt. Sta.

PLATE 7.

my conviction that many trees have been killed by arsenic and that others are hopelessly sick. I will give some reasons for my belief. First, it is a well-known fact that soluble arsenical compounds will kill plants. It has been found that Herbicide, a preparation found on the market, is essentially a solution of an arsenical compound. Both white arsenic and arsenic acid have been shown by various experimenters to be deleterious even when present in very small quantities, one part per million in solution. Second, I took some greenhouse plants, coleuses, daisies and geraniums in two and a quarter and three inch pots and added from 0.05 to 0.5 grams, approximately from 3-4 of a grain to 7.5 grains, of sodic arsenite and the smallest amount used sufficed to kill the plants. Third, I know of two trees, one killed outright, at least this is the testimony of the owner, there is nothing but the stump left at the present time, and the other partially killed. It was my good fortune to see this tree in October last when the affected limb was still on the tree with the dead and blackened leaves clinging to it. Inquiry elicited the statement that it had been killed by arsenic as the other tree had. In the case of the tree that had died and been removed, they had made arsenite of lime under it or near it and had probably spilled the arsenite of soda. In the case of the tree, one limb of which was dead, they had been more careful with their sodic arsenite, having some left over they determined to get rid of it and emptied it into the irrigating ditch near the tree; this was one day in June—two days later the limb was sick. I saw it in October when the limb was dead and had the appearance of having been dead for some time, and again in April last. In the meantime the limb had been cut off but was still lying beside the tree as shown in Plate VI. Mr. Whipple and I measured the distance from the trunk of the tree to the irrigating ditch shown in the foreground of Plate VI., and found it to be 12 feet. An examination of this tree showed that a section of the bark from the base of the trunk up into the big limb was brown, sunken and in appearance like the bark in the trunks of the affected trees. The wood beneath this bark was dead and colored brown, well shown in Plate VII., lower Fig. 2, which shows that nearly the whole section of the limb was involved, and that the bark was sunken and dead. The condition below the surface of the ground was even still more striking for the bark was destroyed and the little that remained was very dark, in places, black. We dug out this root, following it to the irrigating ditch, to the point where the sodic arsenite had been emptied. Two or three feet from the ditch, the root had divided into five branches or rootlets. These were black and brittle. Following these toward the trunk, we could trace the effect of the arsenite by two sections of the bark, one on the upper and the other on the lower side of the root, which had been destroyed and the wood beneath them killed

and blackened. The other two sections of the root were still of a natural color. The roots, two in number which were thrown off to the left of the main root presented a condition contrasting very sharply with the five rootlets and the two sections of the main root for they were apparently entirely normal while the others were black and dead. The condition of this root is shown in Plate VII., Fig. 1, which represents a section of the root taken close to the trunk of the tree—again in Plate VII., Fig. 4, which represents a view of the under side of a piece of this root. The side root was apparently healthy (Plate VII., Fig. 3). The killing of the bark and woody tissue was in this way traced from the point at which the sodic arsenite was introduced into the ditch through the small roots into the large one, thence into the trunk, the limb, and even into the branches. The course was direct and the flow of the poisonous solution was confined to a comparatively narrow channel. The darkened area, "black heart," in the case of these branches is shown in Plate VII., Fig. 1-a and upper Fig. 2, which shows the central discolored area, which is not symmetrical with the annual rings or contour of the limb, and also the border of deeper stained tissue. I am not concerned about any theory of sap circulation, but am simply tracing the discoloring effect of the arsenic through the root into this portion of the branches. We see that the discoloration extends through the root, trunk and central portion of the branch. In this instance, death may be said to have been sudden and it may be assumed that a portion of this effect may be a post mortem one.

We have not simply assumed that the placing of sodic arsenite in the ditch and the dying of this branch of the tree two days later are wholly conclusive as to the cause of death. I have examined the wood of the branches and the root and find an abundance of arsenic in both. In this case, I recovered the largest amount or arsenic found in any sample, namely from the discolored portion of the root, in which I found arsenic corresponding to 34.5 parts of arsenic acid in one million parts of the tissue.

The other portions of this tree were apparently in good condition when I last saw it. An examination of the branches from the unaffected portion failed to show any such case of "black heart" as the affected limb (Plate VII., Fig. 1-b). In fact, they showed nothing which could be classed as a darkened center, though I recall one branch which was clouded more or less.

I have given this case in some detail because I believe it to be as conclusive proof as can possibly be adduced that soluble arsenic compounds not only produce death when introduced into the circulation of the apple tree, but will produce the effects which we find preceding the death of our apple and pear trees. In both cases, we have the killing of the bark, the staining and destruction of the tissue, and the killing of the trees. The "black hearted" condition is

only incidental but in the case of our trees, I believe it to be a very suspicious condition.

I have now given the reasons for my conviction that the arsenic which has accumulated in our soil from the use of arsenical sprays used in combatting the codling moth and other fruit, leaf and bark eating insects is the cause of this trouble. To restate them succinctly, we find the arsenic already accumulated in the soil to an extent far beyond the danger line for solutions as established by competent experimenters. We find it also in the tissues of the plant where it is not normally present; we have proven both in the case of herbaceous and woody plants that soluble arsenical compounds will cause their death.

I regret that I can see no other conclusion than that the corroding of the crowns, the killing of the bark, the staining and final destruction of the woody fiber, the early dropping of the leaves presaging the early death of the tree and its final death a few months later are caused by arsenical poisoning.

SOLUBLE ARSENIC IS PRESENT IN THE SOIL.

In preceding paragraphs, I have made two statements which will help us to explain but in no wise to remedy the trouble. One statement is that the only protection against arsenical poisoning of our orchard trees is the insolubility of the arsenical preparations used in spraying and that their continued immunity from poisoning requires that these arsenical compounds shall not be rendered soluble by any agent in the soil. Again, also in an introductory paragraph, I state that from the standpoint of my own department, this subject was really approached through the study of the effects of the alkalies.

It is certainly true that it is possible that in time, these arsenical compounds might accumulate in the soil to a sufficient extent to enable the feeding roots of the tree to bring enough arsenic into solution to be dangerous to the life of the tree by systemic poisoning. It is useless, however, to dwell upon this possibility when there are known conditions, amply sufficient to explain all the facts. Our soils, especially near the surface, contain from 0.20 of one per cent to upwards of one per cent of alkalies, from 8,000 pounds to upwards of 40,000 pounds of alkalies in an acre foot. A few small areas may be practically free from these salts, but the rule is that they are present. It may be accepted as essentially correct that these salts consist of sodic sulfate and sodic chlorid. There is almost always a small amount of sodic carbonate present, but it is sometimes absent, as is the case in one of the soils in question.

ALKALIES RENDER ARSENIC SOLUBLE.

These so-called alkali salts, sodic-sulphate, carbonate and chloride or to call them by their more common names, Glauber's Salt, Sal Soda, and ordinary kitchen salt, are capable of bringing

the arsenic into solution, even when it is present as lead arsenate. It has often been asked at meetings of these orchardists whether it was a safe practice to use their surface alkali water in applying the lead arsenate and I have stated that it was not a good practice, for one could easily conceive of conditions under which the whole of the lead arsenate could be converted into sulfate of lead and sodic arsenate be formed in the solution. This statement never seemed to be an acceptable one. I have in this case not depended upon any chemical laws, however, evident their adequacy might be, but took well washed lead arsenate, a sample which we found by rigid test to be free from soluble arsenic, suspended one gram of it in 2,000 times its weight of water and added two grams of Glauber's salt, allowed it to stand three days, filtered off a portion of it, concentrated by evaporation and tested it for arsenic. I found that the arsenic had gone into solution in very considerable quantities. A parallel experiment was carried out with salt in which only one gram of salt was used to the 2,000 grams of water. This was not allowed to stand quite three days when 1,500 grams were filtered off, concentrated and tested for arsenic. This concentrated solution was found to be so heavily charged with arsenic, that only a small part of it gave an unmanageable amount of arsenic when brought into an active Marsh apparatus.

A similar series of experiments was made with the lime arsenite. We included in this experiment the salts above mentioned and also distilled water; the lime arsenite was prepared by precipitating a solution of calcic chlorid containing an excess of the lime salt with a solution of arsenite of soda, filtering and washing it. This precipitate was probably the pure normal arsenite of lime. One gram of this lime arsenite was suspended in 2,000 times its weight of distilled water, another gram in a like quantity of water containing two grams of Glauber's salt and a third gram in a like quantity of water to which had been added one gram of salt. The calcic arsenite seemed almost completely soluble in each of the three trials.

We have then direct proof that the alkali salts in the soil are capable of bringing the arsenic, even when present as arsenate of lead, into solution and consequently making it a source of danger.

In regard to the arsenite of lime, there would seem to be but little to be said. I remember having years ago tested the clear solution remaining after the lime and arsenite of lime had settled and as I now recall it, for I have no note on it, the solution was free from arsenic. If this is correct it may have been due to the great excess of lime present.

LIME SALTS IN THE SOIL DO NOT PREVENT THE SOLUTION OF ARSENIC

The idea expressed in the last sentence has persistently presented itself in another form, namely would not the lime salts oc-

curring in our soils, especially gypsum which is notably soluble in water, serve to prevent the solution of arsenic. The answer to this is unquestionably no. For when 500 grams of soil, rich in sulfate of lime, were suspended in 2,000 grams of water and allowed to stand, some arsenic went into solution. This experiment was made three times and the results showed the presence of soluble arsenic so decidedly that there was no reason to seek even for cumulative evidence on this point. It does not, of course, matter where the alkalies came from, whether they were already in the soil or whether they are brought to the soil by the water used for irrigation, some of which I know to be rich in alkali.

CANNOT DISTINGUISH THE SOURCE OF ARSENIC.

I do not know the history of the samples of soil examined whether they contained the arsenic as lime arsenite or lead arsenate, nor does it appear to me to be a matter of importance in which form the arsenic was present in the soil. The experiments with the alkalies, Glauber's salt and ordinary kitchen salt, indicated in my judgment, the greater solubility of the lime salt, but it would be difficult perhaps, aside from the deportment of the lime salt, to prove directly that the arsenic found in the tree had been derived from the lime arsenite for the ash of the tree contains some lime and there is scarcely an orchard soil which has not received both the lead and lime salts. It is impossible to tell which one has contributed more largely to the damage done, but owing to the length of time it has been used and the greater readiness with which it appears to go into solution, it would seem probable that the lime preparation has up to the present, contributed more largely to bringing about the trouble than the lead salt.

It is, on the other hand, easier to obtain direct proof that the lead arsenate has been the source of some of the arsenic for lead is not a normal constituent of woody tissue and the presence of a trace of it suffices to prove that the lead arsenate has been the source of the arsenic. I tested only six of the samples for lead but as lead was found in each of them this number of tests is deemed sufficient. The lead was obtained in the metallic form and its identity established beyond doubt.

The significance of this is not only that lead arsenate has been the source of the arsenic but that the ordinary kitchen salt present in the soil is probably an active agent in bringing it into solution, for the lead chlorid which would be formed by the interaction of the lead arsenate and salt is more readily soluble than the sulfate, the product of the interaction of Glauber's salt and lead arsenate. In this case too, it seems beyond question that both salts, Glauber's salt and ordinary kitchen salt, contribute to the damage done. The amounts of these salts in the soil and in some water used for

irrigation, particularly the Glauber's salt, is more than ample to bring about the solution of the arsenic.

TWO KINDS OF ARSENICAL POISONING.

So far I have not mentioned the character of this arsenical poisoning whether it is a general systemic poisoning or a case of acute irritant poisoning. That the former class of poisoning may occur seems very probable as in the case of one of the pear trees studied but all the rest of the cases with which we have met so far, seem clearly to belong to the latter class. The possibility of the occurrence of the former, however, is a matter for serious concern, for if the soil becomes sufficiently rich in arsenical compounds to enable the roots to appropriate the arsenic as they do the general sustenance of the tree then the poisoning of the tree becomes a question of its ability to tolerate the poison. I fear that we have some cases in which our statement that the beginning of the trouble is at the crown of the tree, is not applicable, though this, as a rule, seems to be the case. Still it is suggestive, as elsewhere indicated, that often the dead roots are not as intimately connected with the affected areas of the crown as those which still retain a little life.

The lead and lime with which the arsenic is combined in the sprays may be appropriated by the tree to its injury. The amount of lime, however, added to the soil as lime arsenite would be wholly insignificant in comparison with the lime already present in nearly all of the soils with which we are concerned in this bulletin unless it were taken up as arsenite of lime.

There are really three substances which might act as poisons to the trees, namely, arsenic, lead and lime.

ARSENICAL POISONING.

I have already discussed the question of arsenical poisoning so far as the purposes of this bulletin demand.

LEAD POISONING.

The question of lead poisoning is a permissible one for discussion, but while lead, as it was found in every sample tested for it, is probably present in all of the samples and may have some influence, the action of the arsenic appears so clearly the important one that the action of lead may be dismissed with this brief mention.

THE EFFECT OF LIME.

This question is one which cannot justly be left wholly without mention. As indicated above the lime and arsenic may be taken up in combination, or it may be simultaneously but not in combination and it would be difficult to distinguish their separate action. There are, however, other questions which involve the case

still further. It is stated on good authority that marly soils are unfriendly to a number of plants. Many of our soils are rich in carbonate of lime and others are underlaid by a stratum of marl, carbonate of lime, sometimes acquiring a thickness of two feet or more. It is a serious question in my mind whether this is not a bad feature. My attitude toward this subject is exactly the same as that toward the one or arsenical poisoning, i. e., that the subject should not be mentioned without good and forcible reasons for doing so. Why mention this then at all?

I have called attention to the fact that many trees, evidently in an unhealthy condition, are bleeding freely from old wounds, stubs, where limbs and branches have been cut off and from cracks in the bark (Plate V., Figs. 1 and 2). This sap is heavily laden with salts of some kind, dries quickly, and deposits a yellowish white crystalline mass. This mass when fresh possesses, at least sometimes, a disagreeable taste; the thoroughly dried salt has not a particularly unpleasant one. I have seen this juice dripping from a crack in the bark and building a veritable stalactite of this material. Mr. Weldon, our Field Entomologist, and I gathered a quantity of this material, avoiding as far as possible the scraping of the bark, lest we should get some of the spray material. The conditions exposed our sample to contamination in this manner and by dust, which might contain arsenic, being blown into it, but I think that the results obtained from this sample may be accepted as, in the main, reliable. This material was very rich in arsenic and contained 25 per cent of calcic oxid. I do not believe that the splitting or cracking of the bark and the bleeding are specific characteristics of arsenical poisoning but are attributable to other causes which in these cases may act conjointly with the arsenic. The destruction of the bark by the arsenic is an entirely different thing from this cracking or splitting of the bark.

Having found that this dried sap was an interesting subject, we gathered a second sample. The preceding sample was gathered before the first spraying of the season had been made, but the second was taken subsequently to it. Lead arsenate was used in the spray and might have gathered in this dried juice which forms rough masses on the limbs and trunk of the tree. In order to remove as far as I might be able, such arsenic as might be present as lead arsenate, dust and other impurities, I dissolved the dried sap in as little warm water, not boiling, as possible and used only the aqueous solution in making the test for arsenic which was very abundant indeed.

This sample of air-dried material gave 24.93 per cent of lime, CaO; it contained a little magnesia and alkalies. I have made no attempt to determine the acid combined with the lime, but lime being practically the only base, it seems probable that the mass is essen-

tially a malate of lime which would require 25.7 per cent of this substance, calcic oxid. These trees do not present the symptoms described for the arsenical poisoning, though arsenic is very abundant. The question is—Are these trees suffering from systemic arsenical poisoning, lime poisoning or both? These soils are marly or have a subsoil of this material and the presence of 25 per cent of lime in the dried sap seems to me to be a very suggestive fact.

I have no remedy to suggest for either condition. Preventive measures are so far as I can see, our only recourse. Those which suggest themselves to me are: to remove the arsenic laden soil from about the crown of the tree and replace it with fresh soil; to use the standard brands of lead arsenate in preference to the arsenite of lime or white arsenic, sal soda and lime; to use as little lead arsenate as possible. I have been told that good results have been obtained by using 2 1-2 and even 2 pounds of pasty lead arsenate to 100 gallons of water, but the spraying must be done thoroughly. Spray no oftener than is absolutely necessary. If I am not mistaken Prof. Gillette has found that 95 per cent of the effect of the whole season's spraying was obtained by the first spraying when thoroughly well done. Some device should be used to prevent the spray material from running down the trunk and collecting at its base or it would be still better to make provision for gathering the whole of the drip. Water rich in alkalies should not be allowed to flow close enough to the tree to permit of the deposition of the alkalies in the soil about the trunk of the tree. Concentrated lye, if used to kill the woolly aphis, should not be applied to the soil at the crown of the tree or permitted to flow down and collect there.

SUMMARY

First: There is a large number of fruit trees in the State which are suffering from an affection of the trunk and root.

Second: This trouble begins, in by far the greater number of cases, at the crown of the tree and subsequently involves both trunk and roots.

Third: The first marked symptom is an early ripening of the foilage usually followed by death about midsummer of the ensuing year.

Fourth: The crown of the tree is found to be girdled, the bark on portions of the trunk dead and sunken and most of the roots dead, their bark destroyed and the woody tissue discolored, usually a light shade of brown and sometimes exteriorly blackened.

Fifth. Soluble arsenical compounds will effect the destruction of the bark, the staining of the wood, the production of the so-called "black heart" and the speedy death of the tree.

Sixth: Arsenical sprays have been used in these orchards for a number of years.

Seventh: These arsenical compounds have accumulated in the soil.

Eighth: The accumulation of arsenic in the soil in an insoluble form has already passed far beyond the limit of danger for arsenic in a soluble form.

Ninth: The insoluble arsenical compounds are being converted into soluble ones in the soil.

Tenth: The alkalies are the agents effecting the solution of the arsenic. By alkalies, I mean, sodic carbonate, sodic sulfate and sodic chloride.

Eleventh: The lime salts, viz. the sulfate, gypsum, and the carbonate do not effectively protect the arsenical compounds from the solvent action of the alkalies.

Twelfth: Systemic poisoning may take place, probably does, by absorption of the arsenic with the nutritive solutions taken up by the feeding roots but the greater portion of the trouble appears to be from local irritant poisoning.

Thirteenth: The arsenical poisoning is, in all probability, in many cases, complicated by lime poisoning.

Fourteenth: The arsenic in the arsenite of lime is more readily brought into solution than that of the lead arsenate.

Fifteenth: It is probable that the lime or marl in the soil and subsoil is also an agent acting conjointly with the arsenic in producing some of the trouble.

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Destruction of Concrete by Alkali

BY

WM. P. HEADDEN

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Destruction of Concrete by Alkali.

BY

WM. P. HEADDEN.

Cement has been found so generally serviceable and beset with so few disadvantages that its use is generally recommended without any reservation, and this confidence has been fully justified with but few exceptions so far as the limited literature at my disposal indicates.

The principal condition under which good portland cement has failed to fulfill the requirements of the structure in which it was used, seems to have been where the structure was exposed to the action of sea water. Such exposure has not resulted uniformly in the destruction of the cement, so that even this condition, i.e., the exposure to sea water, a solution comparatively rich in magnesic chlorid and sulphate, may not have been the determining factor in the trouble noted.

The following case of deterioration may be of some interest as it presents some new points. There were sent to me some months ago a number of fragments of tiling which had been laid but from eight to nine months. They had been disintegrated to such an extent that one of the samples was simply a white putty-like mass mixed with sand. There was nothing about this sample remotely suggestive of concrete. Another of the samples consisted of a fragment of the tile, the interior portions of which had been wholly decomposed, while there still remained an outer and inner portion in good condition, or comparatively so. Another sample had been attacked on the inner side leaving the mass of the tile outside of the zone of decomposition apparently sound. The line of decomposition was sharply limited and showed distinctly, but even in this case there remained a thin layer of cement on the inside.

I do not know whether the tile were running full of water or not, probably not, as the fragments seem to be parts of 16 or 18 inch tile. The importance of this point is simply this, that it would answer any question in regard to the separation of solid "alkali" salts on that portion of the tile above the water line. That such a separation of these salts should take place does not seem very probable in this case.

The point of attack so far as the samples at my disposal indicate, is either in the center of the cement mass or near the inner surface. In either case we are almost compelled to assume the action of the water, i. e., of the salts held in solution. At the same time we see the resisting power of the outside and inside surfaces, which are evidently richer in cement than the inner portion of the mass of the tile.

The sand used in making the tile was quite fine.* The proportion used was 5:1. We can readily see that the individual masses of cement in the interior mass of the tile must be small and readily attacked by solutions of salts capable of reacting with the cement.

It seems quite evident that the agents causing this disintegration of the cement must gain access to the interior portion of the mass of the tile

*I do not know the character of the water used.

in the form of a solution, but it is a question whether this solution is the same in strength and character as the water in the drain. I think that I have clearly shown in Bulletin 65 of the Colorado Experiment Station, page 34, that the water soluble portion of the soil is different from the salts held in solution in the ground water. Further in Bulletin 72, page 28 **et seq.** that the ground waters are different from the drain waters, and the action of these waters on the tile would vary somewhat according to the source of the solution which penetrated the mass of the tile.

The drain waters obtained, say at a depth of four feet, contain as a rule a smaller amount of salts in solution than the ground water. The salts present are the same but their relative quantities vary. The usual salts present in the ground waters are, sodic sulfate, calcic sulfate, magnesic sulfate, sodic carbonate, and sodic, in some instances also magnesic chlorid. In the drain waters we have the same salts but their relative quantities are different, the most notable feature being the relatively large amount of sodic carbonate.

The substances claimed to be the most active in effecting the disintegration of cement are the sulfates. In the case of sea water the explanation offered is that the lime of the cement decomposes the magnesic salts present in the water whereby the lime goes into solution and the magnesia is deposited in its stead, causing a bulging and disintegration of the work owing to its greater bulk. The principal magnesian salt in sea water is the chlorid, the deleterious action of which on cement is not established, but it has been shown that magnesic sulfate acts energetically.* The most active agent in decomposing concrete is the sulfuric acid of the sulfates carried in solution. Again solutions of gypsum have been shown to act detrimentally on concrete by forming with the tri-calcic aluminate a sulfo-aluminate.

The water acting on these tiles whether it be ground water or drain water is very bad. One of the two small samples sent to me contained 1252.6 grains per imperial gallon, of which 493.5 grains were sulfuric acid (SO_3) with an extremely large proportion of magnesia. The other contained 542.3 grains per imperial gallon, with 42.31 grains of magnesic oxid or 7.8 per cent. of the total solids. I have examined a number of waters from this section and find the ground water uniformly heavily laden with the sulfates of lime and soda with comparatively large quantities of magnesia, especially if the water comes from near the surface as it necessarily must in the case of drain waters. In addition to the above constituents, there is uniformly some carbonate present which for the present purpose we may consider as sodic carbonate.

We have then an ample supply of these substances present which are known to act deleteriously upon cement, i.e. the sulphates, a portion of which is magnesic sulfate, and in addition there is so much sodic carbonate present that its action cannot be neglected.

For the present I will assume that the cement used was at least an average Portland cement with not more than two per cent. of calcic sulfate added. Assuming this to be correct, the action of the waters on the tile shows an interesting line of action.

A preliminary examination of the white decomposition product indica-

*Taylor & Thompson Concrete Plain and Reinforced P. 401.

ted the presence of a large amount of water, also of considerable quantities of sulfuric and carbonic acids. The decomposed mass was washed with distilled water to remove as much sand as possible. Examination of the wash water showed that it had taken sulfuric acid, lime and soda into solution. The portion soluble in distilled water may have been partly derived from other sources but probably came, for the most part, from the altered cement. The wash water, therefore, was evaporated to dryness and the residue added to the insoluble portion and the whole dried at 60°C. The material thus prepared was submitted to analysis with the following results; with which is also given an analysis of a sample of the same brand of cement.

PORTLAND CEMENT DECOMPOSED BY ACTION OF ALKALI WATER

	Original Cement	Decomposition Product*	Same calculated on water free basis
SiO_2	22.55	10.98	14.16
SO_3	1.29	15.56	20.07
CO_2	1.07	9.39	12.16
Cl_1	not det'd	0.51	0.65
P_2O_5	......	trace	......
CaO	59.86	29.14	37.58
MgO	1.75	5.79	7.46
Al_2O_3	5.88	2.08	2.68
Fe_2O_3	4.83	2.51	3.23
Mn_3O_4	0.21	trace	......
Na_2O	0.76	1.27	1.63
K_2O	0.63	0.29	0.38
H_2O Ignit. less CO_2	0.72	(22.48)	......
	99.55	100.00	100.00

The loss on ignition in the analysis of the decomposition product agreed fairly well with that obtained by difference, but owing to the presence of alkalies, carbonates and sand the results of direct ignition are not to be relied upon except to show that the difference indicates the amount of water present with reasonable accuracy.

The composition of the water acting on this tiling may safely be assumed to be represented by the following analysis of a sample of Arkansas river water, essentially a return water, taken at Rocky Ford.

The summation of the analysis presents a rather large excess over one hundred which gives an excess of about one grain in the total amount of salts present. The excess of bases shown in the analysis as combined is not necessarily due to bad analytical work. The waters of our mountain streams show an excess of acids over the bases, but the alkalies forming efflorescences on our soils and alkaline waters, frequently show an excess of the bases, but seldom so large as in this case.

*6.01 per cent. sand deducted.

ANALYSIS OF ARKANSAS RIVER WATER, TAKEN AT ROCKY FORD

Total solids per imperial gallon 156.4 grains.

Analytical results.	per cent.	Combined	Grs. Imp. Gal.
SiO_2	0.428	Calcic sulfate	64.942
SO_3	48.299	Magnesic sulfate	27.994
CO_2	1.858	Potassic sulfate	0.942
Cl	4.667	Sodic sulfate	32.449
Na_2O	18.662	Sodic chlorid	12.044
K_2O	0.326	Sodic carbonate	7.007
CaO	17.090	Sodic silicate	1.358
MgO	5.993	Ignition	6.797
Ignition	4.346		
Sum	101.669	Sum	153.533
Oxygen equiv. to Chlorin	1.051	Excess sodic oxid	3.832
Total	100.618	Total	157.365

The ground waters of the Arkansas valley have essentially the same composition; they of course, vary in the amounts of mineral matter, total solids, held in solution. The two small samples of drain water sent with these tiles illustrate this very well, one of them carried 1252.6 grains, while the other carried less than one half as much, 542.3 grains in an imperial gallon.

The salient featurers in the composition of the salts present in the ground waters of this section are the large amount of sulfates and the presence of carbonates. The amount of chlorine or the corresponding chlorids is not large and are probably subordinate agents in the alteration of the cement.

Mr. R. Feret says*; "No cement or other hydraulic product has yet been found which presents absolute security against the decomposing action of sea water." Further, "The most injurious compound of sea water is the acid of the dissolved sulfates." Again the same writer says; "It is noteworthy, however, that chloride of magnesia is almost without action, while the sulfate of magnesia acts energetically upon cement. * * *"

It has further been established by Candlot, Michaelis and Deval working independently, that calcic sulfate unites with calcic aluminate forming a hydrated sulfo-aluminate which expands greatly on crystallizing and is soluble in water.

It is assumed that magnesic sulfate acts upon the calcic hydrate set free by the setting of the tri-calcic silicate, forming calcic sulfate which is then capable of uniting with the calcic aluminate with bad results.

The ground waters found in the lower portions of our irrigated sections contain a mixture of the sulfates of soda, lime and magnesia, with which there is usually associated some carbonate. Some of these waters are essentially solutions of sodic sulfate with a little sodic carbonate; others especially drain waters contain calcic and magnesic sulfates with some carbonate, possibly sodic carbonate.

*Taylor & Thompson Concrete Plain & Reinforced. P. 400.

The knowledge of the fact that our drain waters contain carbonates led me to try the action of a mixture of sodic sulfate and carbonate on the coarsely ground concrete. This mixture attacked the cement rapidly yielding a white decomposition product rich in carbonic acid. This result is no other than what we would expect. If the tri-calcic silicate in setting really liberates four molecules of calcic hydrate, as we suppose the reaction should be accompanied by the liberation of a corresponding amount of sodic hydrate. The following formulae will make this point clear:

$$2(3CaO.SiO_2)+9H_2O=2(CaO\ SiO_2)5H_2O+4Ca(OH)_2.$$

The calcic hydrate liberated or very loosely held can readily act on the sodic carbonate as indicated by the following simple formula;

$$4Ca(OH)_2+4Na_2CO_3=4CaCO_3+8NaOH.$$

The sodic hydrate thus freed is capable of further attacking the silicates and possibly the aluminates, carrying silicic acid, alumina and lime into solution, probably as hydrated silicates. The treatment of the cement with a mixed solution of sodic carbonate and sulfate showed that it is a fact that calcic carbonate is formed and also that silicic, alumina and lime do go into solution and that too without the aid of free carbonis acid.

No care was taken to make the solution of mixed salts even approximately of the same strength, as the ground waters, and no ratio between the salts was observed, simply, that the solution was a weak one; two to three grams of sodic carbonate to the liter with five or six grams of the sulfate The time of the experiment was 14 hours. The time was short, and the solution not as rich in salts as some of our ground and drain waters. The tiles on the other hand are exposed to the action of similar solutions, some weaker but others stronger from the time of being laid till taken out, in this case eight to nine months. In view of these considerations it is not strange that the mass of concrete should be softened and destroyed.

Using the results of these rather crude experiments we may interpret our analyses as indicating that the cement has been deprived of silicic acid; it originally contained 22.50 per cent. but the hydrated decomposition product contains only 10.98 per cent or 14.16 per cent calculated on a water free basis. While the ratio of the weight of the decomposition product to the original weight of the cement is not known, there is no evidence that there has been any increase in the weight which would invalidate the preceding observation and a second experiment with cement and a solution containing sodic sulfate and carbonate leaves no question about the removal of silicic acid, alumina and lime by waters containing these salts. The analyses also suggest the removal of a relatively large amount of lime. The cement contains 59.56 per cent. of lime while the alteration product contains but 37.58 per cent. (calculated on a water free basis). Further the ferric and aluminic oxids have been reduced to about one half as much in the decomposed cement as there was in the original. The sodic sulfate, more particularly the calcic and magnesic sulfates which are present in the ground water will at the same time act on the tri-calcic aluminate, forming the sulfo-aluminate $2(3CaO\ Al_2O_3)+5CaOSO_3$, which crystallizes with 60 molecules of water and is soluble. That these reactions really have taken place is indicated by the increase of the sulfuric acid SO_3 which amounts to 20.07 per cent. and likewise of the carbonic acid which amounts to 12.16

per cent. of the water free decomposition product, while they amount to only about 1.0 per cent. each in the original cement.

That the magnesic sulfate also participates in producing the deterioration is indicated by its presence in the altered cement to the extent of about five times the amount present in the original; i.e. 7.46 per cent. in the water free alteration product against 1.75 per cent. in the original.

The changes effected in this case are quite consonant with the views quoted excepting the formation of so large a proportion of carbonate, evidently calcic carbonate due to the action of the sodic carbonate in the ground water. The presence of sodic carbonate in a solution so rich in lime may seem improbable, but this has been shown to be not only possible, but a fact.

This alteration product differs materially from those produced by the action of sea water on the works at Aberdeen and analyzed by Prof. Brazier (Redgrave and Spackman, Calcareous Cements. p. 285.) according to which the chief decomposition products were calcic carbonate with calcic and magnesic hydrates, while the amount of the sulphuric acid was scarcely altered at all. The analyses indicate a removal of the ferric and aluminic oxids from the interior portions of the work, and an increase of them in the outer portions. The authors after giving the analyses justly make the following statement: "We may observe with respect to these analyses that both in the case of the original cement and the deteriorated concrete, there are many matters which we are quite unable to reconcile."

The action of the ground waters seems to have been one of chemical change converting the lime of the cement into a sulfate and carbonate accompanied by the removal of silicic acid, alumina and lime and totally destroying the cohesiveness of the concrete.

The samples of deteriorated tiles sent to me do not justify any inferences whatever in regard to the part that may have been played by the expansive force of newly formed crystallizable compounds. The thickness of the tile and the amount of material involved is so small that this factor is negligible and the results presented are probably wholly due to chemical action.

This subject is of some importance as concrete structures, bridges, culverts, foundations, etc., are being erected in places where they will be subjected to the action of such waters.

Most of the cretaceous shales are, so far as my observation goes, rich in alkalies, calcic sulfate, etc., and concrete foundations laid in these may be acted on prejudiciously.

As the work in this article was about completed, I received Bulletin 69 of the Montana Experiment Station. The attention of the writers of this bulletin, E. Tappan Sannatt, and Edmund Burke, was called to the deterioration of the cement mortar used in the construction of the sewer system of Great Falls, Montana, by the City Engineer, C. W. Swearinger.

This bulletin gives some excellent illustrations of deteriorated mortar and a general description of the conditions as they found them, also some suggestions relative to their local conditions and recommendations in regard to foundations and other structures made of concrete, but there is no chemical work done on the cement and the products of its alteration. Such work is promised for some future time.

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A Few Orchard Plant Lice

BY

C. P. GILLETTE
AND
E. P. TAYLOR

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B. O. LONGYEAR, B. S.,	Assistant Horticulturist
E. B. HOUSE, M. S.,	Assistant Irrigation Engineer
F. KNORR, B. S.,	Assistant Agronomist
P. K. BLINN, B. S.,	Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S.,	Potato Investigations
MIRIAM A. PALMER,	Artist
L. C. BRAGG,	Ass't in Entomology

State Fruit Investigations

O. B. WHIPPLE, B. S., Grand Junction,	Field Horticulturist
GEORGE P. WELDON, B. S., Delta	Field Entomologist

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A FEW ORCHARD PLANT LICE

C. P. GILLETTE AND E. P. TAYLOR*

Among the worst insect enemies of the Colorado orchadist to-day are a few species of plant lice. The codling moth used to be our queen of orchard pests, but the apple growers have learned to successfully combat this insect by means of arsenical sprays.

The plant lice, or aphids, illustrated and discussed in these pages, are not the only ones that fruit growers have to contend with, but they are the species needing the closest attention at the present time in Colorado orchards, and when one has learned to combat these, he will be able to apply the proper remedies for the destruction of most other kinds that he is likely to come in contact with. It has been thought best to give a rather full account of the life habits of the lice here mentioned so that the fruit grower may better understand the methods of control.

The colored plates have been prepared at considerable expense that the reader may better recognize these pests. We believe the bulletin will help those who read it to understand that different plants have different species of lice infesting them, and that these lice often have very different life habits and require different means of control. The lice that infest any plant never appear spontaneously, but every louse, like every higher or larger animal, is the offspring of a parent of the same kind. Consequently all the lice that infest our plants were either native, living upon Colorado wild plants before white men came here, or they have been carried to our orchards upon nursery stock from other parts of the world.

GENERAL STRUCTURE AND HABITS OF THE PLANT LICE (*Aphididae*).

There are a large number of species belonging to the group of insects commonly designated as "aphids" or "plant lice," which have a remarkable similarity of structure and general habits. A knowledge of the more important structural characters of these

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*The general direction of the studies here reported, the determination of species, all descriptions, and many of the field and insectary records were made by the writer of this note. The extensive field experiments with remedies upon the Western slope, as well as many life history and food plant notes, were made by Mr. E. P. Taylor, while acting as Field Entomologist for this station. A large portion of the life history and food plant notes, both in the field and in the insectary, have been by Mr. L. C. Bragg. The illustrations are all by the department artist, Miss M. A. Palmer, with the technical descriptions before her. Miss Palmer always draws from her own measurements of parts and when her measurements and mine do not tally, we reach a joint agreement before she proceeds. So I believe the drawings will be found, structurally, quite reliable.

The technical descriptions, with some additional notes upon life habits, have been sent to "Journal of Economic Entomology" for publication.—C.P. GILLETTE.

lice is necessary to enable one to distinguish the species from one another or to understand the descriptions. A knowledge of the general habits will be of great service in enabling one to decide what remedies to employ for the destruction of any of these lice when found infesting plants in general.

EXTERNAL STRUCTURE OF THE APHIDS.

The more important structural parts of an aphis are clearly shown in Fig. 1. The antennae upon the head are special organs of touch and probably smell also. By means of them the insect is able to find its food plants and its mates. The cornicles, standing out from the posterior part of the abdomen, are little tubes through

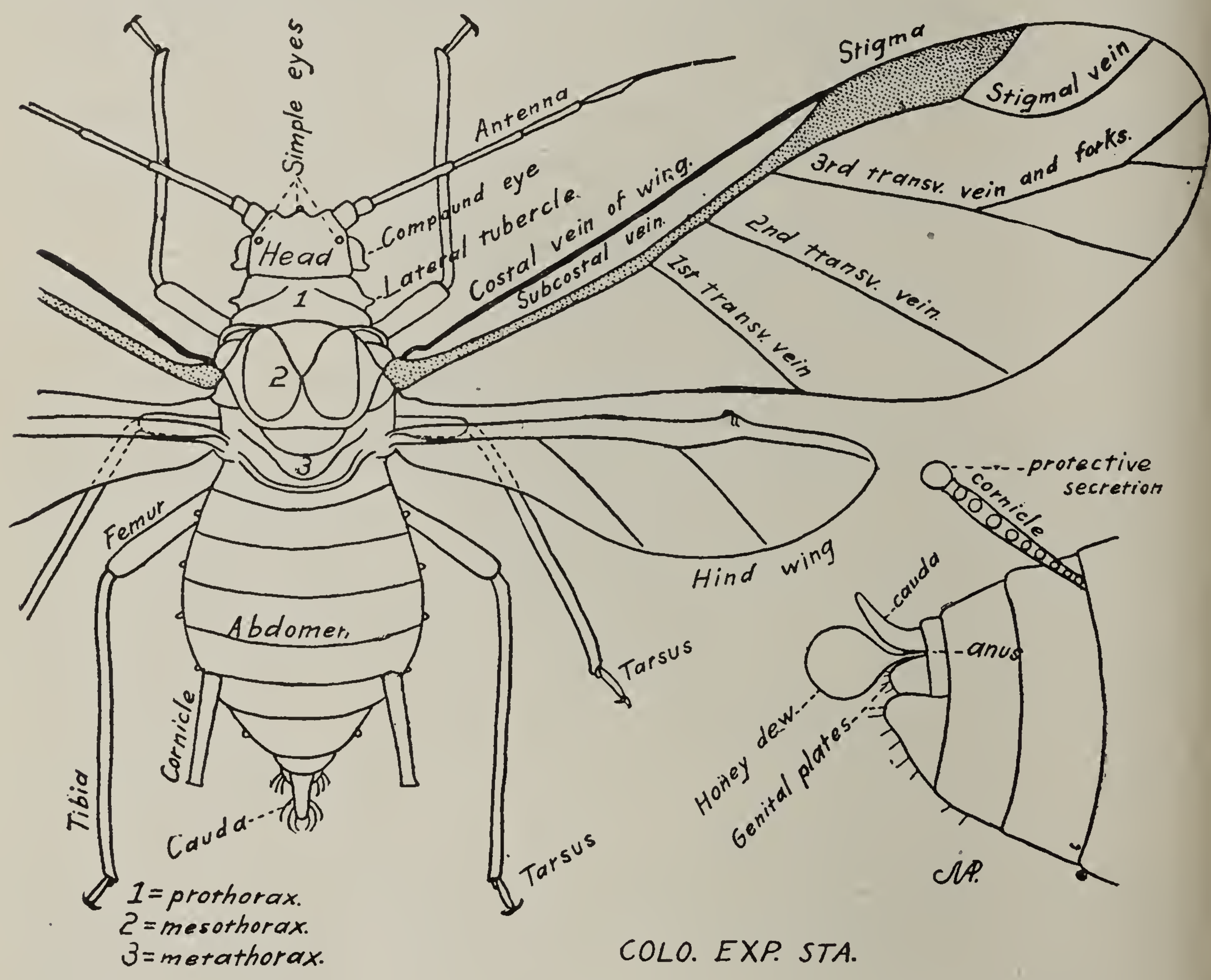

Figure 1. External Structure of an Aphis.—M. A. Palmer, artist.

which the louse expels a sticky material of various colors in different species, as green, yellow, red, black, white, etc. This secretion is probably for the purpose of defense against enemies, but these organs are never for the purpose of expelling the little clear drops of "honey dew" which are so eagerly sought after by ants and sometimes flies, bees and wasps, for food. The honey dew is expelled from the anal opening beneath the cauda, as shown in the smaller drawing, Figure I. The beak, through which the lice

suck the sap of plants, is beneath the head and does not show in the figure.

Each species of plant louse has its special food-plant or plants upon which it feeds. Some species are very restricted in food, having but one, or at most a very few closely allied plants, to live upon, while other species have a few preferred plants but also attack others in smaller numbers, and under certain conditions may adopt a very wide range of plants, especially in the spring, when nearly all growth is tender and succulent, and again in the fall after the preferred food plants may have ripened or have been killed by frosts.

Perhaps one of the most important things to be known, from an economic standpoint, is that very many plant lice have a regular alternation, or change, of food plants. Such lice usually migrate upon certain trees or other woody plants in the fall, upon which eggs are deposited to remain over winter and hatch in the spring to start the next year's broods. These spring forms, after going through one or more generations, acquire wings and go, either wholly or in part, to their summer food-plants, which are usually plants that will die down in the fall.

But it is a condition that we face. The lice are in our orchards. How can we recognize them? What are their habits? How can we prevent their injuries to the fruit crops? These are the questions we shall specially attempt to answer, for the fruit growers.

APPLE PLANT LICE

THE WOOLY APPLE APHIS

(*Schizoneura lanigera* Hausm.).

Plate I, Figs. 9, 10, 11, and Plate III, Figs. 3, 4.

If Colorado orchardists should vote their opinion as to what ought to be called the worst orchard pest in the state, it is very doubtful whether the codling moth, or the woolly aphis, would carry off the honors.

Most plant lice are leaf feeders, but this one confines its attacks to the tender bark, and it is not particular whether it is the bark of the trunk, limbs or roots, if it is only tender enough to enable the louse to insert its beak. When very abundant the lice sometimes attack the stems of the leaves and fruit.

PAST HISTORY.

No one seems to have determined with much certainty the native home of this insect. In fact, it may be said to be a louse without a country, as it is everywhere disowned. The earliest references to it that we have found dates back to 1787, when it was

reported upon apple trees in England. Harris, in his "Insect Injuries to Vegetation," states that the louse had been known in France several years earlier than this. In 1801 it was reported in Germany by Hausmann, who described it and gave it its scientific name. In 1810 it had become so abundant in Gloucestershire, England, that the farmers feared they would have to stop making apple cider, and it is still a serious pest there. In England it was early believed that this insect was first introduced upon nursery stock from America. Buckton, an English writer, in his "Monograph of British Aphidides," seems to believe that this louse is a native of America, and states that it has been known to occur upon the American crabapple;* but the first record we have of the occurrence of the woolly aphis in the United States is in Harris' "Insects Injurious to Vegetation," published in 1841, more than a half-century after it had become a recognized pest in Europe.

In England, before the real cause of the mouldy appearing trees had been discovered, this malady was called American blight. On account of the blood red stain, caused when this louse is crushed, the Germans have called it the blood-louse. But wherever this insect may have its native home, and whatever may have been its native food plants, we know that it now occurs in practically every apple-growing region on the globe and, as it is an insect of much economic importance in Colorado, we shall go rather fully into its habits, life history, and means of control.

THE LOUSE DESCRIBED.

Most orchardists will think a description unnecessary, and to them it would be were it not for the fact that there are many other woolly lice upon other plants that are frequently mistaken for the woolly aphis of the apple.

The name woolly aphis was given because of the white secretion occurring so abundantly upon the wingless lice, and, to some extent, upon the winged ones also. This is not a woolly covering in the sense that it grows like wool or hair. It is really a fatty or waxy secretion similar to the shellac, China wax, or beeswax of commerce. Small glands beneath the skin give off delicate white threads of this material through minute pores. This white secretion, when warmed, will melt like tallow. It is easily removed from the body, but in a short time the body will be covered again. It serves as a protection to the louse against storms, and, to some extent, no doubt, from its insect enemies.

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*Buckton probably had in mind the statement made by Fitch in his first N. Y. report, p. 5, in which he says he has seen the winged form of the woolly aphis numerous in groves where he suggests that it had come from the shad-bush (**Amelanchier sp.**). It is altogether probable that Fitch mistook the winged form of **Pemphigus corrugatus** Sirr. for winged migrants of the woolly aphis of the apple.

The body beneath the wool is of a rusty or purplish brown color in the fully grown lice, but the very young are much lighter colored. The winged lice are recognized in patches of the white secretion by their long, dusky wings. The thorax and head are black, or nearly so; the abdomen is a dark yellowish brown, and the legs, eyes and antennae are also black or blackish. The last lice in the fall, those that live over on the tree above ground (Fig. 11), are of a dark yellowish to dusky brown color, without the cottony secretion, and would not be recognized as the same insect at all by one not familiar with this stage in the life history of this insect.

LIFE HISTORY.

The life history of this pest of our apple orchards is most wonderful, some stages of which are still not well worked out. Upon the roots, the wingless lice may be found in all stages of development at any time of the year, reproduction and growth taking place more slowly or ceasing entirely in cold weather. Apparently the weather is never cold enough to kill the lice that are well beneath the surface of the ground. We have occasionally found winged lice beneath the surface of the ground when digging about the roots of trees, but we have never found the true males or females or eggs upon the roots. So the lice are always carried through the winter in large numbers upon the roots of the trees, and many of the small lice have often been seen in the spring and early summer migrating up the trunks of apple trees, some of which, undoubtedly, lived over winter upon the roots, or are the offspring of those that did. This does not mean that there is anything like a general migration of the root-lice upward in the spring, for we have no reason to think that such is the case. Neither do lice that are half-grown or more seem inclined to change their locations. Only the very young seem to travel about.*

Upon the trunks and branches of the trees we have, then, four possible sources of the lice in the spring; the little brown lice that descended mostly to the crowns of the trees in the fall to spend the winter; lice from the roots, whose ancestors lived upon the roots the previous summer; young lice of the last fall brood that were able to withstand the rigors of the winter upon the trunk and branches, and lice hatching from eggs that were deposited the previous fall by the sexual females.

From our observations, the most important of these sources is the first mentioned, and the least, if of any importance at all,

*Since writing the above, a letter from Mr. George P. Weldon, Field Entomologist, located at Delta, Colo., dated June 25, '08, says: "I notice only very small lice are trapped in Tanglefoot bands, indicating that the larger ones do not migrate at all."

the last one. Much careful observation has not rewarded us by the finding of a single sexual male or female or an egg of this louse out of doors upon an apple tree under normal condditions. Professor F. V. Theobald, of the South-Eastern Agricultural College, at Wye, England, in his "Report on Economic Zoology," 1907, says: "The egg stage takes place close to the base of the tree, always, however, above ground level. These ova remain frequently hidden in the crevices of the bark all the winter, and in spring they produce a larva which soon matures into the 'mother-queen' form, and which sets to work at a great rate to produce viviparous young." Whether Professor Theobald is reporting his observations or is reasoning from analogy we are unable to say. We know from the actual observations of the writers and by Mr. L. C. Bragg, that such a method of procedure is pursued by the elm woolly aphis, *Schizoneura americana.* The fall winged lice of this species that give birth to the sexual forms sometimes accumulate in thousands about the bases of elm trees to deposit the sexual forms, but we have been unable to discover such a habit for the woolly apple aphis. We are not averse to believing that it has such a habit, but we have not been able to discover it and do not feel sure that Prof. Theobald intended to announce that he had for this species.

During the winter of 1906-07, when the thermometer barely reached zero in the Grand Valley about Grand Junction, and only reached —9.3 degrees at Fort Collins, the lice lived over winter in large numbers upon the trunks and branches. As a result, in the Grand Valley especially, this louse was the most numerous the following spring and summer that we have ever known it in the state. Fortunately, the lady beetles (Plate II, Figs. 12, 13, 14, 15) aphis-lions (Plate I, Fig. 15), and syrphus larvae, came through in good condition, too, so that by the first of August scarcely any of these lice could be found anywhere in Colorado above ground.

Last winter (1907-8) the temperature went several degrees lower, and at Fort Collins there were several nights when the temperature went below zero, yet quite a number of the little, dark, over-winter form of this louse lived through in old scars and beneath the dead bodies of the lice of the previous fall.

How many of those that migrate upward from the crowns of the trees in the spring are really from the roots, and how many are the over-winter form from the tops that went down in the fall, it is impossible to state with certainty. Tanglefoot bands put about the trees early in the spring caught large numbers of the ascending lice at the lower margin and apparently the greater proportion, early in the season, were the over-winter form.

If the lice have lived over in any great numbers, a man with a good hand glass (which every fruit grower should have) can easily detect the fresh white secretion appearing in the old scars.

All the lice appearing upon the trees or roots during spring and summer are viviparous females. That is, they are lice that give birth to living young without the intervention of males. Probably these lice live about three weeks after becoming mature, during which time they will give birth to from 75 to 125 young. These young require about ten days to mature and, like the parent, give birth to their quota of young and die. This process continues generation after generation, all the lice being wingless and viviparous until about the first week in September, when in some of the colonies, winged viviparous females will begin to appear in small numbers. They soon leave the colonies and take wing, and to the present time we have entirely failed to determine what becomes of them. When inclosed by cheesecloth so they cannot escape, they persist in crawling about over the walls of their cage and never return to the tree. Before dying, they give birth to the true male and female lice, but this is either done upon the walls of the cage or upon the inclosed trees. They act like a fall migrant of a louse having an alternate food plant and possessed of an instinct to desert the old one. It is possible that the bad behavior of the lice has been due to the artificial conditions under which they have been studied. We believe Professor Alwood was the first to observe and describe the true male and female of this louse,* and his observations also were confined to the laboratory.

The winged viviparous females appearing in the fall give birth to from six to twelve young, about half of which are males and half females. These egg-laying females are yellowish brown in color and are about half as large as the common adult apterous females. The male is rather light yellow in color and is considerably smaller than the female, and neither grow after being born, having no mouth parts with which to take food. The female develops one large yellow egg that is fully two-thirds as long as her own body. The female is also wingless. Ten winged females were dissected and from them were obtained males and females, as follows:

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* Bull. 102, Virginia Experiment Station, p. 139, and Spec. Bull. (C. P. C. No. 45), p. 12, of the same station, 1904.

MALE AND FEMALE BIRTH RECORD OF WINGED MIGRANTS

	MALES	FEMALES		MALES	FEMALES
Louse -----1	4	5	Louse --- 9	2	4
" -----2	5	5	" ---10	4	5
" -----3	3	5	" ---11	3	6
" -----4	3	5	" ---12	4	5
" -----5	3	4	" ---13	4	5
" -----6	4	1	" ---14	3	4
" -----7	5	2	" ---15	4	5
" -----8	3	2	" ---16	4	3

In a state of nature these remarkable instincts and life habits were not developed without a very deep-seated cause. One purpose seems to be to enable the aphis to get away from its mortal foes and continue its existence. The lady beetles * and other predaceous enemies are likely to become so numerous late in the season as to exterminate the colonies of woolly aphis, but if such a thing should happen, the eggs deposited by the true females will start a number of new isolated colonies another spring away from the old haunts of the enemies, and in this manner greatly increase the probability of the continuation of the species. Probably another equally important consideration is the increase of food supply through the dissemination of the species.

When cold nights come on, about as winter apples are being picked, many of the young lice (Fig. 11) do not locate, take on a dusky to dark greenish color, do not grow or secrete any cotton or shed their skins, and seem to be developed for the special purpose of withstanding the winter's cold to start another round of woolly aphis life the next spring.

If a tree top is badly infested, these specialized young will crawl down the trunk in countless thousands in the fall. We have often seen them abundant enough to very perceptibly darken the trunk of the tree and the earth for some inches about the crown. Great numbers crawl into crevices in the earth, about the crowns of the trees, and others get into every possible hiding place beneath loose bark, in cavities of rotten limbs, in old scars and other places that will afford a little winter protection.

Apparently, all the lice in our Colorado climate that insert their beaks and begin taking nourishment in the fall are killed when severe freezing weather comes on. By far the greater num-

*We have found **Hippodamia convergens** to be by far the most abundant lady beetle attacking this louse. **Coccinella transversalis, C. transversoguttata,** and **C. monticola** we have also found feeding upon them to some extent.

ber of the over-winter lice perish, but a few find sufficient protection to enable them to withstand the cold and they start new colonies in the spring. Our tanglefoot bands have caught large numbers of these lice upon the lower half in the spring, and enormous numbers in the upper half in the fall.

PARTS OF TREE MOST ATTACKED.

A great deal of digging about the trees in orchards of the Western slope proved that very little harm is done to roots that are more than 10 inches below the surface of the soil, and more than three feet from the crown of the tree. If water sprouts are allowed to grow up about a tree, they are almost sure to be very lousy, especially just at the ground.

Succulent and rapidly-growing parts, especially grafts, are very susceptible to attack.

Of all the varieties grown in Colorado, the Missouri Pippin seems to be worst infested, and Northern Spy is practically exempt. We have yet to find a single tree of this latter variety much infested. In a few instances slight infestation has been found in pears.

Loose, porous soils seem more favorable for the development of this louse upon the roots than are the heavier and more compact soils.

INJURIES.

The woolly aphis belongs to a gall-producing group of plant lice. Their punctures in the bark have an irritating or poisoning effect, which results in an increased flow of sap, which is to the advantage of the louse, and at the same time it causes an abnormal growth of the part. Very small rootlets may have lumpy galls of considerable size (Plate III, Fig. 4), and larger roots may have an aggregation of these swellings involving a large portion of the root surface. As a result of these attacks, the roots often die and rot and sometimes the condition is so bad that a tree may be pushed or blown over because of the number of roots that have died near the crown of the tree. When the lice attack the tender bark about a scar, upon trunk or limb, the new growth is made more or less gnarly, but the effect is not so pronounced as upon the roots. The lice also attack the tender bark of the small limbs, and particularly where rapid growth is taking place, so that grafts and water sprouts are usually worse infested than other portions of the tree. Upon these rapidly growing parts the lumpy growths often become very numerous. The galls are usually smooth but often crack open, and especially is this true in cases of severe infestation.

If this louse is very abundant, either upon roots or limbs, the result is an unthrifty tree, bearing small and poorly colored fruit. Even if the fruit is worth picking it will be more or less smeared with the excretions of the lice, and the pickers may have their clothing almost completely colored with the red juices of the crushed lice.

Probably the injuries to the tree are greatest from the root attack, but the direct losses to the orchardist are doubtless greatest from the injuries to branches and fruit.

PREVENTION.

Prevention is usually much better than any remedy, but we are seldom aroused into action until we are hurt, and money spent on preventive measures is likely to be considered money thrown away. The greatest care should be exercised to avoid setting young trees with woolly aphis already upon them. Such trees have a severe handicap from the first. To avoid this handicap purchase trees, so far as possible, from nurseries that send out clean stock and then insist on your nursery stock being thoroughly inspected by a competent person and, if infected, either reject it or insist upon thorough disinfection.

One way to prevent the root injuries of this louse is to plant only such apple trees as are grown upon Northern Spy roots.

If nursery stock is received with the roots "puddled," covered with mud, insist upon the mud being thoroughly washed off so as to expose the roots for inspection. This is one way nurserymen have of covering up the woolly aphis on the roots.

As we find that the lice seldom are found upon roots more than ten inches from the surface of the ground, this is a strong hint that the soil for a successful apple orchard should be deep, and that planting, cultivation, and irrigation should be so managed as to make the trees deep rooted. Set the trees rather deep, irrigate thoroughly but not often, and cultivate deeply, from the first, between the rows.

Finally, during the last half of August, before the winged lice appear, thoroughly spray for the purpose of cleaning up the lice upon the tree tops, so that the winged migrating form can not spread about to distribute the species to other trees.

NATURAL ENEMIES.

Notwithstanding the fact that this louse is heavily covered with a protective waxy secretion, it is freely preyed upon by lady-beetles (*Coccinellidae*), Syrphus flies, and Chrysopa larvae, commonly called aphis-lions or lace-wing flies. The orchardist will often notice that certain limbs or trees that were badly infested early in July may be nearly or quite freed from the lice by the

middle of August. We had an excellent illustration of what the predaceous insects can do in this way last year. Probably this insect never was so abundant in the orchards of the state as they were last year, from their first appearance in the spring until about the middle of July. About that time the enemies had become so abundant that a noticeable decrease soon became apparent and by the 10th of August it was almost impossible to find a living louse above ground. Upon the roots there was no noticeable change in the infestation. The enemies then left the trees, and the few lice that were overlooked. with a few others that migrated upward from the roots, soon began to increase in numbers, so that by the last of September the trees were showing a light infestation again. Apparently this is all easily explained. The winter of 1906-7 was very open and mild, so that plant lice of all kinds lived through unusually well and were very abundant early in the spring. As a result, there was a very abundant food supply for their enemies, which also increased with great rapidity, so that by the first of August they began to get the upper hand of the lice, and to prevent their own starvation, almost completely ate the latter from every exposed place. In the Grand Valley the greater portion of this benefit was done by the lace-winged fly (Plate I, Fig. 15), while upon the Eastern slope the lady-bettles (Plate II, Figs. 12, 13, 14, 15) were the chief benefactors, with the lace-winged flies and the Syrphus flies as efficient helpers in the good work. Specimens of a small black parasitic fly* were taken by Mr. L. C. Bragg, ovipositing in this louse at Fort Collins, August 20, 1908.

REMEDIES ABOVE GROUND.

Wherever this louse can be reached by sprays, it may be destroyed, like any other plant louse, but one important precaution is necessary, the spray must be applied with sufficient force to wet through or remove the woolly covering. This louse is then more easily killed than is the green apple aphis, which curls the leaves for protection.

There are several spray materials that may be used with success. In fact, any spray that is generally successful when used for the destruction of plant lice may be considered useful for the destruction of this insect.

KEROSENE EMULSION.

When properly made, a good kerosene emulsion has no superior, as a spray for the destruction of the woolly aphis, so far as we have been able to determine, and it penetrates the woolly covering better than most insecticides. When used in the usual strength of 1-15 (7 per cent.) oil we have always found it to be suffi-

*Aphelinus mali (Hald.), determined for us by Dr. L. O. Howard.

ciently strong. A preparation of 1-20 (5 per cent.) oil is usually successful if thoroughly applied and makes a spray of very moderate cost. Directions for the preparation of kerosene emulsion are given near the end of the bulletin. The trouble, if any, will be in obtaining a good emulsion from which the oil will not separate and collect upon the surface. To be successful use a moderately coarse and forceful spray. While we are inclined to consider a good kerosene emulsion the most efficient of all the insecticides we have used against the woolly aphis, we are aware that most orchardists have had so much trouble making it that they prefer to use something more easily prepared, even at a somewhat increased expense. Such men as B. A. Smith, F. C. Jaquette, Joseph Cornetto, E. M. Cheedle, W. K. Haines, and others in the Grand Valley, have used the emulsion with the best of results.

SCALECIDE AND OTHER MISCIBLE OILS.

There are upon the market a number of so-called miscible, or soluble, oils which, when put into water, break up into very fine particles and form a milky white emulsion. These, like kerosene emulsion, make a very good and efficient spray for lice if they do not separate to form a film of pure oil on top. The only preparation of this kind that we have used at all extensively is Scalecide. When used as strong as 3 to 4 per cent. oil we have found it very effectual. Apparently the soluble oils have to be used with more care than kerosene emulsion on account of their liability to injure foliage when too strong.

SOAPS.

In our experiments for several years past some of the standard whale-oil or tree soaps have given very satisfactory results, but, for some reason, the orchardists have not seemed to be as successful with the soaps they have used. We have used chiefly the brands sold as Good's Whale-oil soap, and Bowker's Tree-Soap, and 1 pound to 8 gallons of water has usually been sufficiently strong. The warmer these soaps can be when applied, the better. We believe the soaps can be purchased so as to be among the cheapest of spray materials, and if anyone has been using a brand that has given him success, we see no reason why he should make a change. Mr. A. L. Roberts, of Paonia, reported to us last year that he completely cleaned the woolly and green apple lice out of his orchard by thoroughly spraying with 13 pounds of whale-oil soap and 1 gallon of Black Leaf to each tank of 220 gallons of water.

"BLACK LEAF."

The Kentucky Tobacco Product Company, of Louisville, Kentucky, manufactures a tobacco extract which they sell under the

above trade name and which has become very popular among the orchardists of Delta County as a spray for all plant lice in their orchards. Purchased in car load lots, it is one of the cheapest, and most easily prepared, of all spray materials used, and has given remarkable satisfaction, and in our experiments it has given splendid results. Aside from the fact that it does not penetrate the woolly covering of the lice quite so readily as the kerosene emulsion, we are inclined to place it about on a par with that insecticide in its killing effects. When this, or any other spray, is used, special care must be taken to throw the spray from all directions and under high pressure, 140 to 180 pounds, if possible, to get best results. The manufacturers write us that they take great pains to put out a uniform product of Black Leaf so far as the nicotine content is concerned, and that this is the only ingredient that it contains that has any special insecticidal value. This being the case, if the manufacturers keep up the present standard of quality in this dip, we predict that it will come into very general use for the destruction of all aphids upon out-of-door plants.

While the orchardists have been using Black Leaf, in most cases, in the proportion of 1 gallon to 65 gallons of water, we have found in our experiments, where we know that thorough treatments have been made, that 1 gallon to 75 gallons of the watery mixture is very uniformly successful in killing all the lice, and 1 to 100 (a 1 per cent. mixture) seldom fails to give excellent results.

It is a good plan for the orchardist to treat a few trees with varying strengths of his mixture a day or two before taking up his spraying in an extensive way, and note carefully the results. In this way he may save many dollars, either from using the insecticide in strengths that are unnecessarily strong, or by throwing away a large amount of time and material in the application of a spray that is too weak to give satisfactory results.

TOBACCO DECOCTIONS.

Some may prefer to make their own tobacco sprays, either by using tobacco stems, tobacco dust, or whole-leaf tobacco. While fruit growers do not report very uniform results from their own tobacco preparations, our experience has been different. When we have steeped tobacco stems, or tobacco dust, in water in the proportion of 1 pound to two gallons, or the whole-leaf tobacco in the proportion of a pound to four gallons of water, we have been very uniformly successful in getting a decoction that would kill the lice. See directions for preparing tobacco decoction near the end of this bulletin.

Mr. W. S. Coburn, President of the Colorado State Board of

Horticulture, tells us that he has had excellent success by using tobacco of his own raising in the proportion of 1 pound to 6 gallons of water after steeping for a full hour and then applying warm.

LIME-SULFUR SPRAYS.

Lime-sulfur sprays used during the summer, when the lice have a wooly covering, have not proven satisfactory in our experience. For early spring spraying, see below.

Chloroleum, potash lye, and strong lime washes have also been tried without marked beneficial results.

LATE WINTER OR EARLY SPRING APPLICATIONS.

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were partially freed from the woolly aphis also.

We have no doubt but what kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps, could be used successfully as early spring sprays for the destruction of the over-winter lice upon the tree top, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time, if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then, as a final act for best results, put tanglefoot bands about the trunks of the trees so that the lice at the roots cannot migrate to the top. For the application of these bands, see next paragraph.

TANGLEFOOT BANDS.

In the experiments upon the Western slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan, and is

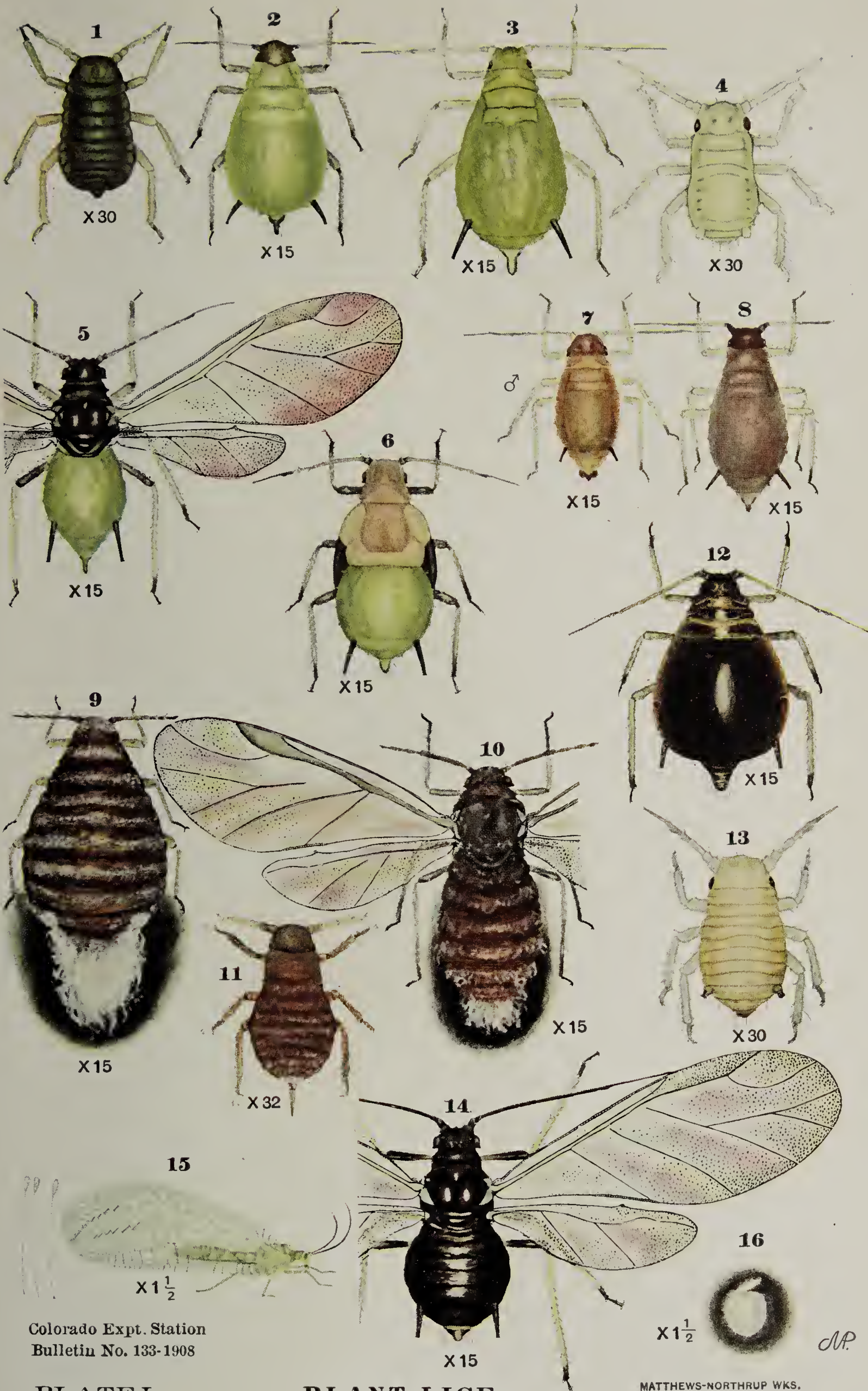

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PLATE I

PLANT LICE

MATTHEWS-NORTHRUP WKS.
BUFFALO

similar to the sticky material put upon the Tanglefoot Fly-paper. When at all abundant upon the trees, the newly-born lice are much inclined to travel about, and it is often astonishing to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Mr. Weldon, field entomologist, reports these bands doing harm to trees, where they have been on for more than a year. The Tanglefoot was placed directly upon the bark, but it would be safer to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING.

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree, but they get down to them directly from the surface above. So far as possible, the descending over-winter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration, both to and from the roots, can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compacted after a rain or an irrigation.

TRIMMING.

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths, and a thorough thinning of the top so that plenty of sunlight can enter, has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

TREATMENT BELOW GROUND.

The treatment below ground is all aimed at the lice that are

within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below, if they can only be put in contact with the lice. The orchardist should be cautious, also, not to accumulate in the soil, about the crowns of his trees, substances that are likely, either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY.

For many years tobacco, in the form of dry dust, stems or leaves, has been considered the best known remedy for this louse. Soapy solutions have also been thought of some value. In Bulletin 23 of the Georgia Experiment Station (1907), Professor R. I. Smith, reports far better success with kerosene emulsions than with tobacco or soaps for the destruction of the apple woolly aphis upon roots.

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given in the table on the following page.

The authors are under special obligations to the men who kindly offered their trees for the experiments and in other ways aided in carrying on the work.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following. The materials used upon the roots were kerosene emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, Adams' lime-sulfur, whale-oil soap, and carbon bisulfide, as shown in the table. Other tests were also made upon the roots which are not scheduled.

Before making the applications, the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins, which varied some in depth and diameter, with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. Both the treated trees and the checks were given a rating of 1 to 4 as to degree of infestation, so as to be able to make fair comparisons in determining results. The liquid applications were then forcefully sprayed upon the roots in these basins until two or three gallons had been applied, and when the liquid had nearly or quite soaked into the

EXPERIMENTS FOR THE DESTRUCTION OF THE WOOLY APPLE APHIS

Orchard of	Insecticides	Strength	Treated	Date Used	Examined
L. P. Nissen	Lime and Sulfur	15, 15, 50	Tops and Roots	November 7, 1906	Nov. 19, '06
	Chloroleum	1 to 40	Tops		Nov. 23, '06
	“	1 to 50	Tops and Roots		Nov. 28, '06
	Scalecide	5% oil	“ “		Jan. 11, '07
	Tobacco Dust	2, 4, 5, 6 and 8 lbs.	Roots	Nov. 23-28, 1906	Mar. 15, '07
	Tobacco Stems	2, 4, 5, 6 and 8 lbs.	“		Mar. 25, '07
	Quick Lime	10 and 20 lbs.	“		June 6,07
	Rex	1 to 11	Tops	—Mar. 25, '07	
	Ker. Emulsion	7% oil	As Bands		
	Tanglefoot				
H. D. Smith	Ker. Emulsion	22.2% oil	Tops	December 18, 1906	Summer, '06
	“ “	16.6% oil	“		Jan. '07
	“ “	13.3% oil	“		
	Scalecide	1 to 19 (5%)	“		
	Tanglefoot			June as bands	
R. E. Turpen	Rex L. S.	1 to 8 with lime	Tops	March 2-22, 1907	April 26 1907
	Adams L. S.	“ “ “ “	“		
	“ “	1 to 8 with no lime	“		
	Lime and Sulfur	1—1—2	“		
	“ “	1—1—3	“		
	“ “	1—1—4	“		
E. M. Cheedle	Rex L. S.	1 to 8 no lime	Tops	March, 1907	June 5, '07
	Tobacco stem Decoction	1 lb. to 1 gal.	“	Apr. 2-6, '07	Aug. 22, '07
	Ker. Emulsion	7% oil	“	Mar. 1 to Apr. 6	June 5, '07 Aug. 22. '07
F. C. Jaquette	Whale-oil Soap	1 lb.—4 gal.	Tops	April 2	
	Ker. Emulsion	9.4% oil	“	April 2	
	Ker. Emulsion	6% oil	Roots and Tops	April 9	April 9 to June 7
	Ker. Emulsion	6% oil	Roots	June 7	June 20
	Checks				
	Carbon Bisulfid	3 oz. to tree	“	April 11	May 16
B. A. Smith	Lime Sulfur Rex & Adams		Tops		
	Tobacco Dust Decoction	1 lb.—2 gall.	“		
	Tobacco Dust Decoction	1 lb.—3 gall	“		
	Ker. Emulsion	5% oil	“	Mar. 2 to 6	Mar. & May
	“ “	6% oil	“	Mar. 2 to 6	“ “
	“ “	7% oil	“	May	“ “
J. Cornetto	Ker. Emulsion	3, 5, 6, 7, 10, 15 20, 33, and 50% oil	Roots	June 26 to July 2	July 22
	“ “	5 and 6% oil	Tops		August 22 and Sept. 13
	Black Leaf	1 to 50	Roots		
	“ “	1 to 66	“		
	“ “	1 to 75	“		
	Tobacco Dust	1 lb. to 1 gal., 1 lb. to 3 gal., 1 lb. to 5	“		
	Tobacco Stems	2 lbs,—1 gal,	Roots		
	“ “	1 lb.—1 gal.			
	“ “	1 lb.—3 gal.			
	“ “	1 lb.—5 gal.			
	Tobacco Stems	6 lbs. per tree	Roots		
	Scalecide	1—40, 1—60, 1—50	Roots		

ground, the basin was filled again and the earth banked well about the trees. In hard, compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3 per cent. to 50 per cent.), killed the lice well when the roots had been well treated. Where less than 6 per cent. of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where 7, 10 or 15 per cent. of oil was used, the effect was still more lasting, and the 20, 33 and 50 per cent. treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

The trees in the above experiment were examined later by Mr. George P. Weldon, who reported upon the effects of the various applications, as follows:

EXPERIMENTS IN THE ORCHARD OF J. CORNETTO.

"Grand Junction, Colorado, July 10-11, '08.

"I am disappointed to find that the wooly aphis is very abundant on all of the roots of treated, as well as check trees, in the experiment, even where a 50 per cent. kerosene emulsion was used. Where this strength was applied, the odor of the soil is still very pronounced when then earth is stirred, and the trees show severe injury from the application. The roots are being killed and the leaves are wilting, and it is probable that the trees will soon die. A comparison of the treated trees with the check tress does not indicate that any benefit from the various treatments has continued to the present time. Even where the 50 per cent. oil was used, the lice are as abundant as upon the check trees in the experiment. There are almost no lice above ground upon any of the trees at this time. With the exception of the 50 per cent. kerosene emulsion treatment, none of the applications seem to have done any harm to the trees.

"Roots treated with tobacco dust, even where eight pounds to a tree are used, do not show any indications of benefit from the application now.

"In the Jacquette orchard I find that the Tanglefoot bands that have been on for two seasons are doing serious injury to the bark of the trees, especially upon the south side."

Some orchardists have reported to us that they believe they have had trees sickened and even killed from the kerosene emulsion that accumulated about the roots at spraying time, and one or two have reported applying kerosene emulsion to the roots of apple trees during the winter for the destruction of the woolly aphis and that the trees all died after a few years. So, while we know that kerosene emulsion is a very effectual destroying agent for woolly aphis on roots, we are inclined to advise those who use it to be cautious and to keep a close watch of their trees and stop farther treatments as soon as any signs of injury appear. It might be well to select a few trees that one does not care very much for and

treat them somewhat severely with the thought that so long as they show no injury, it is probably safe to treat others more lightly.

CARBON BISULFID.

This insecticide has often been reported successful against this insect upon the roots.

A splendid opportunity was afforded to observe its results in the 20-acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks before being completed.

At the beginning of the treatment a trench 4 or 5 inches deep was dug encircling the tree and about 3 to 4 feet in diamater. Three ounces of liquid carbon bisulfid were poured into the bottom of the trench, and moist earth thrown quickly in and packed down with the shovel. This method did not seem successful, and another process was substituted. A shovel was thrust deeply into the ground about 18 in. to 2 ft. from the base of the tree with the blade broadside to the tree. The handle was then tipped forward and the carbon bisulfid poured in at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. Care was taken not to pour the liquid directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as 3 cents per tree.

Observations on May 16th showed some good accomplished, especially where the infested roots had been near to the points where the bisulfid had been poured, but there were many living lice still remaining about the crowns of the trees. The soil at time of treatment was loose, friable and moist, but not wet. The results seemed to indicate that such a treatment would be profitable in cases of severe root infestation, but not as effective as kerosene emulsions or tobacco decoction applied directly to the exposed tree roots.

Tobacco Dust and Stems have not given very satisfactory results in our experiments nor with most of the orchardists who have tried them. Where 5 or 6 pounds to a tree has been used directly upon the exposed roots and about the crown, followed by a thorough irrigation about the trees, we have had reports of good and poor results, even when thoroughly irrigated at once to soak the juice down about the roots, so we do not think tobacco dust or stems can be relied upon for satisfactory results.

Tobacco Decoctions in which 2 pounds of stems, or dust, or 1 pound of whole leaf tobacco was used to each 3 gallons of water and

forcefully sprayed upon the exposed roots gave fairly good results, but these were not equal in their killing and repelling effects to a 10 or 15 per cent kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well, but had very little repelling effect afterwards.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were "Chloroleum," lump lime (10 to 20 pounds to a tree), potash lye, wood ashes, salt and flooding with water for several hours.

ROOT TREATMENT OF NURSERY STOCK

Apparently none of the inspection laws have prevented, though they have greatly lessened, the shipment of trees infested with woolly aphis. It is commonly recommended to dip or fumigate such trees to destroy the lice.

We have found the ordinary dipping process quite ineffectual in cases of severe infestations on account of the protection afforded by the woolly secretions, but we have had perfect success by untying the bundles and forcefully spraying the trees upon roots and tops with kerosene emulsion (7 to 10 per cent oil), or one of the tobacco or soap preparations used for top treatment. *Make the spray forceful and drench all parts.* It requires but little time or material to treat thousands of trees. Where this work is to be done on a large scale, a water tight spraying surface or pan could easily be arranged with a drainage tank so that the same spray material could be used over and over.

Dipping for 6 seconds in water heated to 140 degrees Far., and fumigating for 40 minutes in hydrocyanic acid gas we have also found efficient remedies for the destruction of this louse on nursery trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7 per cent kerosene emulsion, Black Leaf dip 1 pound to 60 gallons of water (or some other strong tobacco decoction), or a good whale-oil soap, 1 pound to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7 per cent emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10 per cent kerosene emulsion, Black Leaf dip (1 to 50), 2 to 3 gal-

lons to a tree, or, if the soil is quite open and porous, carbon bisulfid*.

THE GREEN APPLE APHIS

(*Aphis pomi DeGeer.*)

Plate I, Figs. 1 to 8, and Plate III, Fig. 5.

This insect was first described in Europe by DeGeer in 1773 and two years later was described by Fabrecius as *Aphis mali.* It is not known when it first appeared in America, but Mr. Theodore Pergande has been quoted as saying that he first saw it here in 1897. In 1900 Dr. J. B. Smith gave excellent descriptions of this louse in its different forms with an account of its habits in Bull. 143 of the New Jersey Experiment Station. This seems to be the first published account of what we are calling the "green apple aphis" in this country. Now it is known to be very generally distributed throughout the country, being readily carried upon nursery stock in the egg stage.

The dry climate of Colorado seems favorable for the development of this louse and its natural enemies have not been sufficient in recent years to keep it in check without the aid of spray pumps and insecticides.

Sanderson's statement* that *A. pomi.* "is, however, by no means as common as *A. fitchii*" (really *avenae*), surely does not apply at all to Colorado, where the latter species, in all the apple growing sections, is a comparatively rare insect and one that we have never found occuring in abundance upon a single tree. *A. pomi* is one of our very worst orchard enemies, and is, also, the species most commonly brought into the state in the egg stage, upon nursery stock.

FOOD PLANTS

This louse spends its entire life cycle upon the apple and pear trees and does not, so far as we have been able to observe, leave these trees during a portion of the summer to feed upon other plants, as so often occurs with other species. So one need never fear that this insect will migrate from the apple and pear trees to other fruits or vegetables, and it is equally true that it will not migrate to the apple and pear trees from weeds or vegetables, as it does not infest them.

Besides the apple and pear, this aphis also attacks the hawthorn, the quince and the flowering crab, but the cultivated apple seems to be its favorite food plant. Among the apple trees it has its preference. The Missouri Pippin seems to be its first choice

* Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

* Thirteenth Ann. Rep. Del. Ex. Sta., p. 131, 1901.

while Rome Beauty, Black Twig, Ben Davis and a few others are close seconds, and the Northern Spy is scarcely attacked at all.

This insect gets its food by inserting its beak and sucking the sap from either the leaves or the rapidly growing, softer and more tender twigs. For this reason rapidly growing young trees, grarts, and water sprouts are worst infested. When upon the foliage, this louse feeds, for the most part, upon the under side of the leaves, which curl in such a way as to give it considerable protection from the direct rays of the sun, and from sprays that are not used with force and thoroughness.

LIFE HISTORY

Like most insects, this green aphis has very definite life habits. Probably we cannot do better than to begin with the egg and follow it through its different stages of development.

THE EGGS

The winter is past entirely in the egg stage upon the twigs of the trees that were infested the previous fall.

Many lice select the axils of buds and rough places in the bark for the deposition of their eggs, but this one seems to prefer the free surface of the rapidly growing shoots. When the lice are abundant, the water sprouts, in particular, are often fairly blackened with eggs (see Plate III, Figure 5).

When first deposited, the eggs are light green in color, but soon become shining black from the action of the sunlight upon them. They are long oval in shape and are just large enough to be plainly seen by one who has good eye sight. By actual measurement it would require 40 of these eggs, placed end to end, to extend one inch.

Very few of the eggs ever hatch, according to our observations. On the eastern slope, at least, it seems doubtful if more than one per cent hatch in average years. Even this small percentage of the eggs hatching is sufficient with the rapid rate of increase to enable this insect to become destructively abundant before fall. When the time arrives for the little louse to come from its winter quarters, the shell splits longitudinally upon the upper surface near one end and the prisoner, with much writhing and kicking works itself out. No definite date can be fixed for the hatching. The first lice were found emerging in 1907 at Palisades just as the first apricot blossoms were opening. At that time the apple blossoms were but little swollen. In a general way it may be said that the lice begin to hatch a little before the apple buds show any green and continue to hatch for two or three weeks, depending upon whether the weather is warm or cold most of the time.

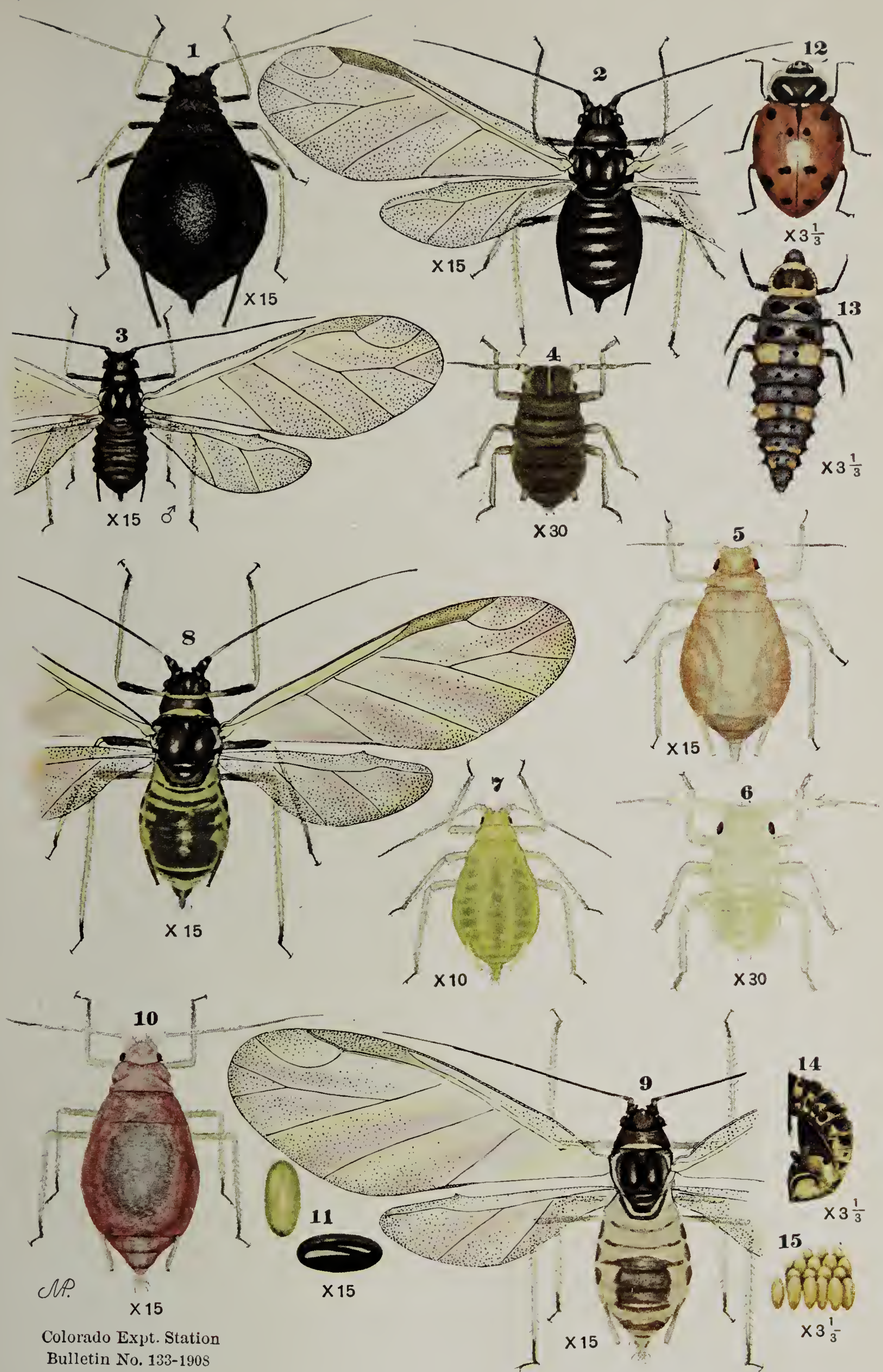

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PLATE II

PLANT LICE

M.-N. WORKS
BUFFALO

THE STEM MOTHERS

Plate I, Figs. 1 and 2.

The lice hatching from the eggs in the spring are all females, and are called "stem mothers" because from them spring all the succeeding brood of the year. No other lice of the year are quite like these that come from the eggs. The little louse upon first hatching is very dark green in color while other young of the year are very light yellowish green (Plate 1, Figs. 1 and 4). If the buds are not yet open, the stem mothers are able to live a few days for the buds to swell enough to enable them to insert their beaks into the tender tissue of the young leaves for their first meal. As soon as the buds open enough to make it possible, the little lice work their way down into the folds of the opening leaves where they are protected from the cold and from the lady beetles and other insect enemies and the death dealing sprays of the orchardist. In about two or three weeks, if the weather is warm, our stem-mother will have attained full development and will begin to give birth to living young at the rate of 3 or 4, to 10 or 12 a day. During their whole life these stem-mothers differ in appearance from any of the later broods of the year. They never get wings, are of a rather dark green color with a conspicuously dark colored head; the antennae are shorter and usually six, though they may be seven jointed; the cornicles are rather short and black and the cauda or tail is also black. The stem-mother is usually a little smaller than her grown children and grand children, measuring only .06 of an inch (1.50 mm.) in length when fully grown. (See Plate I, Fig. 2.)

SECOND GENERATION

As soon as the stem mother becomes fully grown, she begins to give birth to living young which constitute the second generation. Each female may deposit as many as 75 to 100 young during a period of two or three weeks and then she dies. These young are all female which, like their parent, are capable of giving birth to living young. We have found a very small percentage of the second generation getting wings. So the winged lice may begin to scatter from tree to tree and orchard to orchard at Grand Junction about May 10th, and at Fort Collins about June 1st. It is not until the 3rd. generation that the winged lice appear in large numbers, so that the migration of winged lice is not usually noticed until about the first week in June in the warmer orchard sections in Colorado, and two or three weeks later in the colder portions. After mid summer the winged lice begin to grow fewer in numbers and disappear entirely about September 1st.

WINGLESS FEMALE OF SUMMER GENERATIONS

Plate I, Fig. 3.

The summer wingless females (all after the stem mother) when fully grown, are a trifle larger than the first generation, are yellowish green in color, have 7 joints to the antennae, both antennae and cornicles are longer than in the stem mother, and the cornicles, cauda and the greater portion of the antennae are black. These females continue until late fall and are very prolific, giving birth to living young.

WINGED FEMALES

Plate I, Fig. 5.

The winged females also give birth to living young lice. They fly about to other trees and so establish many new colonies, some of which will be likely for a time to escape being found by their enemies.

These winged migrants are not numerous until the third brood and they continue to appear in considerable numbers until about the last of August, when they soon disappear, and true sexual males and egg-laying females take their places.

About the first of September* males and egg-laying females begin to appear. The males and females pair and the latter begin to lay eggs about the middle of September and continue to do so until killed by severe freezes.

MALES

Plate I, Fig. 7.

The male is wingless, is yellowish or rusty brown in color, and is much smaller than any other adult lice of the year.

EGG-LAYING FEMALE

Plate I, Fig. 8.

The egg-laying female is considerably larger than the male, but is smaller than the other female lice of the year and is yellowish green in general color with considerable variation.

NATURAL ENEMIES

This louse is attacked by about the same natural enemies as the wooll aphis. The Lady Beetles seem to us to be the most efficient as destroyers of it though the syrphus flies and aphis lions (lace-wing flies) also kill great numbers. They are almost never attacked by parasites, in fact the only parasitic attacks that we have seen have been by a minute Chalcid (*Alphalinus mali*)* that causes the lice to change to a deep coal black while they retain their natural size and shape.

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* Our earliest date for males at Fort Collins is September 4.
* Determined for me by Dr. L. O. Howard.

Sometimes the orchardist thinks that ants are destroying the lice upon his trees. This is never the case. The ants visit the lice for their sweet secretions and are careful not to harm them and they ever stand ready to drive away many of the enemies of the lice.

REMEDIES

The remedies to use against this insect, from the time the buds open in the spring until the leaves drop in the fall, are the same as those given for the woolly aphis above ground. Kerosene emulsions that is one-fifteenth oil and Black Leaf dip, 1 part in 70 parts of water, are the two most favored sprays at the preent time in Colorado.

WINTER AND EARLY SPRING SPRAYS

For several reasons, late winter and early spring are most favorable for the destruction of the green apple aphis. The orchardist usually has more time then in which to do the work; the foliage being off, it requires less pains, time and material to make a thorough treatment, and by spraying early one avoids destroying the plant louse enemies which are killed along with the lice in summer spraying. If the work is well done in early spring, the trees should be free from lice until the winged migrants have flown in from neighboring orchards and established their colonies upon the trees. Such orchards will seldom become seriously infested before July, if they are at all during the summer, so they are sure to make their growth unhindered and will seldom fail to mature their crop in good condition.

Professor Aldrich seems to have been the first to report success from winter treatment of orchards for the destruction of the eggs of plant lice.* He reported very satisfactory results from the use of lime-sulfur sprays made by both the 1-1-2 and the 1-1-4 formulas (1 lb. lime, 1 lb. sulfur, and 2 gallons water; and 1 lb. lime, 1 lb. sulfur and 4 gallons water), but did not succeed in destroying the eggs with emulsions of kerosene oil.

In our experiments for the destruction of eggs we have found the oil emulsions useless, killing only in very high strengths, if at all.

The treatments that we have found quite successful for the destruction of eggs are:

Lime-Sulfur mixture, 1-1-2 formula, sp. grav. 1065.
Lime-Sulfur mixture, 1-1-3 formula, sp. grav. 1045.
Rex Lime-Sulfur, 1-8 strength, sp. grav. 1055.
Rex Lime-Sulfur, 1-4 strength, sp. grav. 1080.
Black Leaf, 4 per cent strength.

* Bull. 40, Idaho Exp. Sta., 1904.

Black Leaf, 3 per cent strength.
Black Leaf, 2 1-2 per cent strength (a little weak.)

THE CLOVER APHIS

(*Aphis bakeri* Cowen)

Plate III, Figs. 1, 2.

This louse was described by Mr. Cowen in Bull. 31 of this station in 1895. *Aphis cephalicola* Cowen, described from heads of white clover, is the same species.

On April 13, of this year we found a red-stem-mother of some unknwn aphis rather common, and in many cases fully grown, upon the buds of apple and pear trees about Delta, Colorado. The color varied from a dark green streaked and mottled with red to a deep dark red, with cornicles very short and pale yellow throughout. At this time the apple buds were just beginning to open and peach trees were nearly in full bloom. It seems probable that these stem-mothers must have hatched fully two weeks prior to this date to have become fully grown. The green apple aphis (*A. pomi*) at this time was just hatching and none were found that were more than half grown.

The identity of the louse was not suspected until the department artist, Miss M. A. Palmer, suggested that the second brood lice looked like her drawings of the clover louse, *A. bakeri*. A careful comparison indicated that the two forms were identical except for a little difference in color. This second generation (the offspring of the stem mothers) were light green or yellowish green in color, while *bakeri*, upon clover, is pink or yellowish. A large pale orange blotch surrounding each cornicle is also quite characteristic. Sprigs of apple infested with this louse were put in a cage with red clover and the lice in all stages readily adopted the clover as their food plant. Later the pink form was also found upon apple and crabapple (*Crategus sp.*) and no doubt was left that all were one species with varations in color.

FOOD PLANTS AND LIFE HISTORY

Summing up the life habits of this insect from all the observations we have upon it in the records of the Experiment Station for the past nine years we conclude as follows:

The clover aphis, *A. bakeri*, infests the cultivated and sweet clovers and alfalfa throughout the warmer part of the year where, apparently, it never occurs in the oviparious form nor as eggs. In the fall, a portion of the winged lice migrate to apple and pear trees where eggs* are deposited to live over winter and hatch into the red stem mothers the following spring. The descendants of

* Oviparous females and eggs we have not seen with certainty.

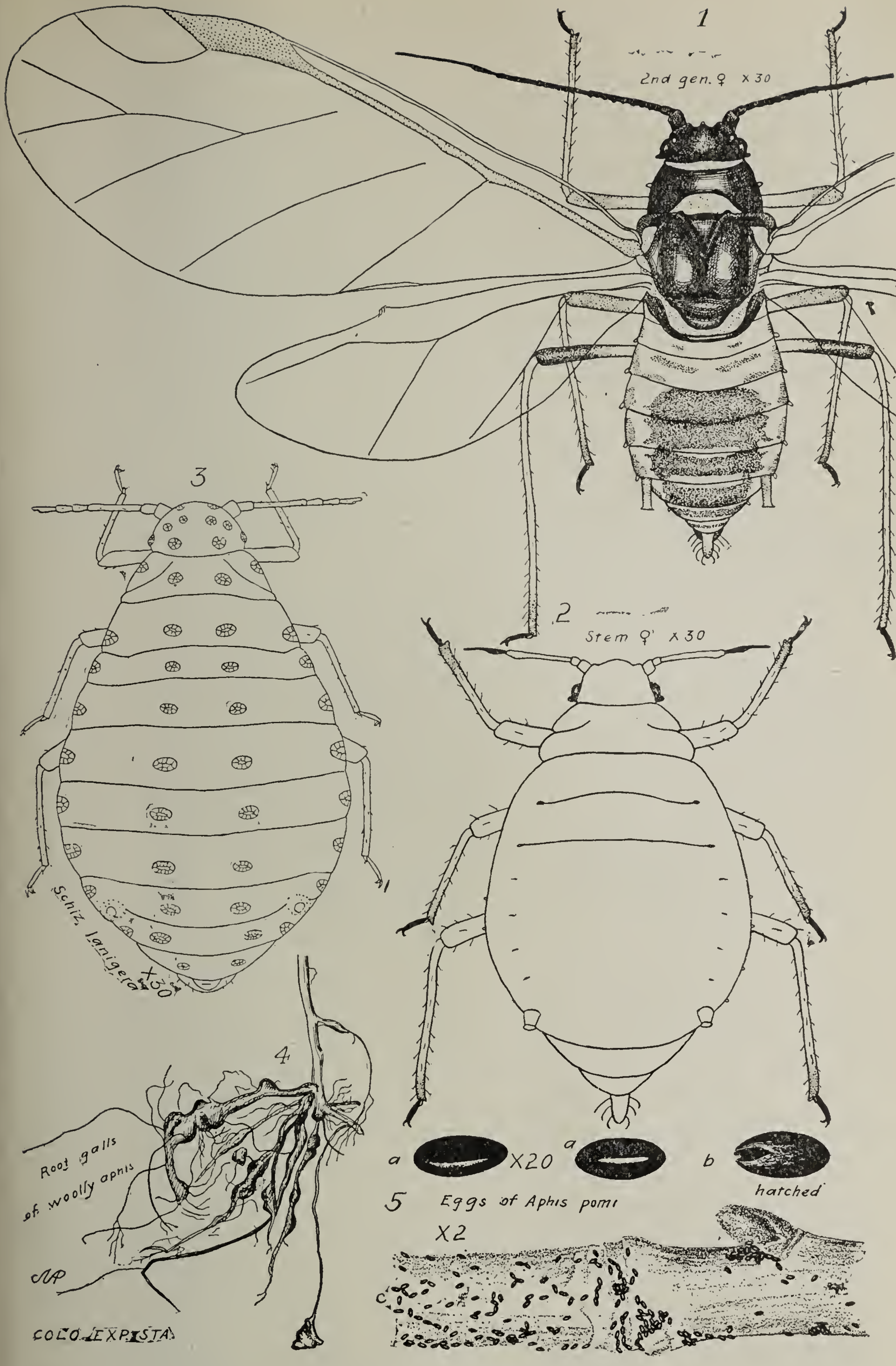

PLATE III. Fig. 1. Winged viviparious female of **Aphis bakeri;** 2. Stem mother of **Aphis bakeri;** 3. Wingless viviparious female of **Schizoneura lanigera** showing wax glands; 4. Root galls of wooly aphis of the apple; 5. Eggs of the green apple aphis **(Aphis pomi),** a. Eggs much enlarged; b. Egg shell after the louse had hatched; c. Apple twig with eggs upon it. Figures 1, 2, and 3 are enlarged 30 diameters; figure 5, a. and b. enlarged 20 diameters, c. enlarged 2 diameters. M. A. PALMER, Artist.

these stem females begin in the second generation to get wings and by the middle of June nearly all have left the trees and gone back to the clovers,** though some remain on the apple all summer. In the fall, many of the lice continue upon the clovers, going down close to the ground as cold weather comes on, and if the winter is not very severe, many will survive and continue to live and increase upon these plants throughout the year. Mr. L. C. Bragg has carried this louse through the winter in the laboratory upon red clover without trouble, but no eggs or egg-laying females were obtained.

So far as our observations have gone, this louse ranks next to the green apple aphis (*Ahpis pomi*) in numbers as a leaf infesting species of the apple. Mr. George P. Weldon reports it as having a tendency to accumulate in the apple blossoms, but we can hardly consider it a serious pest as yet in Colorado orchards.

Remedies the same as for the green apple aphis except that the application to kill the stem-mothers should be applied earlier, fully a week before the leaf buds begin to open at all.

THE EUROPEAN GRAIN APHIS

(*Aphis* (*Siphocoryne*) *avenae* Fab.)

This louse was found in a few apple orchards in the Grand Valley in 1907, and during the spring and early summer of 1908 it was observed in small numbers upon fruit spurs and succulent sprouts upon the trunks and large limbs of apple, pear and quince, in the orchards about Delta, Paonia, Montrose and Rockyford. Mr. Weldon reported it on apple at Montrose as late as June 18. In no case has it been found in sufficient numbers to do appreciable harm. In our experience the apple has been the preferred tree, and colonies upon the pear and quince have been rare.

This louse is readily separated from any of the other species here mentioned by the alternating transverse stripes of light and of dark green that cross the body above, by the light colored cornicles with black tips that are present in both young and adult forms, and by the very short second fork in the third transverse vein of the fore wing of the winged forms. It curls the leaves in a manner similar to the green apple aphis, *Aphis pomi*.

This insect was first described in Europe by Fab., as a grain louse, and it was not until 1894 that Mr. Theodore Pergande* discovered that it also feeds upon the leaves of apple trees during a portion of the year. It is said to be the most abundant apple leaf aphis of the eastern states.

** July 8, and again Aug. 16, '08, several colonies were found on apple about Fort Collins. Mr. Weldon reported this louse on apple at Delta, Colo., July 12, '08.

* Bull. 44, Div. of Entomology, U. S. Dept. of Agr.

LIFE HISTORY

The lice that first appear in the spring, the stem-mothers, hatch quite early, before the buds begin to open at all, from little shining black eggs that were deposited upon the bark of the twigs the preceding fall as in case of the common apple aphis. These stem-mothers are fully as forward as those of the clover aphis. They were mature and depositing young of the second generation in the orchards about Delta as early as April 14th this year.

The stem-mothers are rather deep green in general color with the head and tail ends of the body lightest in color, and the green may or may not take the form of lighter and darker transverse stripes. They do not acquire wings.

These first lice give birth to young for two or three weeks, or somewhat longer, and then die. Some of these second generation lice get wings and leave the trees. What lice are left produce a third generation which more largely become winged and leave, according to Pergande, to go upon certain grasses, especially oats, wheat, barley, and rye, where they continue to increase in numbers until late in the summer or early in the fall, and the winged migrants leave the grains and grasses again and return to the trees. Here they probably give birth to the true males and females, the latter of which deposit the eggs to remain over winter and hatch the stem-mothers to start the complex round of development for another year. (We have not yet traced the fall stages, nor have we been able to colonize it upon the grasses from the apple.)

We have not prepared technical drawings for this louse*

THE ROSY APPLE APHIS*

(*Aphis pyri* Boyer.)

A rosy tinted aphis of doubtful determination appeared in con-

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* For illustrations of this louse see Pergande's figures, Bull. 44, Bureau of Ent.; also Sanderson's 13th Rep. Del. Exp. Sta., p. 139.

* This seems undoubtedly to be the louse that Sanderson described and figured in the 13th Annual Report of the Delaware Experiment Station (1901), as **Aphis sorbi.** Quaintance, Circular 81, Bureau of Entomology (1907), considers this to be **Aphis malifolii** Fitch, but Fitch describes this louse as being "of a shining black color throughout," and also states that "the legs are entirely black." None of the lice we have taken fill these requirements. Specimens of **Aphis sorbi** from Europe sent by Dr. Cholodkovsky and taken by him from **Sorbus aucuparia,** the original food plant of this species, fit well into Kaltenbach's description, and are doubtless that species. While the Colorado material possesses the four dorsal spines in front of the cauda and has the general color markings of **sorbi,** the dorsal tubercles are smaller and the lateral tubercles of the abdomen and thorax are much weaker. The larvae and pupae sent by Dr. Cholodkovsky have the cornicles unusually large and strongly tapering, while in our material the cornicles are not excessive in size. On the whole, our Colorado louse seems more nearly to correspond to the descriptions and figures of **Aphis pyri** Boyer, as given by Koch, and also by Buckton, and these descriptions and figures seem also to correspond very well with the **characteri-**

siderable numbers upon individual trees in some of the orchards of the Grand Valley last year. It attacks the leaves, causing them to curl exactly as in the case of the green apple aphis, but it is readily distinguished from that species by the pink color, especially of the wingless forms, and by the slight covering of a white powdery material. The winged lice have their head and thorax nearly black, but the abdomen is yellowish or rusty brown about the margins and dark brown over the middle portion, and never green or black as in the other species mentioned upon the apple. We are calling this, rather doubtfully, *Aphis pyri Boyer.* Remedies the same as for the green apple aphis (*Aphis pomi*).

THE SWEET CLOVER APHIS

(*Aphis medicaginis* Koch.)

This small black plant louse, while having a decided preference for certain legumes, as the sweet clovers, the locos, black locust, and wild Licuorice (*Glycyrrhiza lepidota*), feeds to some extent upon a very wide range of plants. We have frequently found it upon tender new shoots of apple and other fruit trees early in the season, and have received inquiries concerning it.

The wingless lice, when fully grown, are very deep shining black. Other wingless individuals of the colony are dark green to slaty gray but not black. From these colors alone the orchardist will be able to distinguish this from other species attacking the apple. Whether the colonies of this louse upon the apple came from stem-mothers hatching from over winter eggs has not been determined. We have never seen the eggs or true sexual forms of this species anywhere. It is not likely that this louse will ever become a serious orchard pest.

PEACH PLANT LICE

THE GREEN PEACH APHIS

(*Myzus persicae* Sulz.)

Plate II, Figs. 5 to 11.

This is by far the most abundant peach louse in Colorado. It seems to have been brought to this country from Europe where it was first described by Sulzer as a peach insect in 1761. Forty years later Shrank, finding it upon *Dianthus* (the pink) gave it the specific name *dianthi*. Koch in Germany redescribed it under

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zation of malifolii, as given by Fitch. So we are calling our rosy apple aphis **Aphis pyri** Boyer, until we get further light upon the subject.

It might be added that the **Aphis sorbi** described by Buckton, Vol. II, p. 83, and which is referred to by Schouteden as this species in his paper ("Catalogue des Aphides de Belgique," p. 228), in "Memoires de la Soc. Entom. de Belgique, T. XII," is not **sorbi** unless both the descriptions and the illustrations are very incorrect, and the specimens we have from Dr. Cholodkovsky incorrectly determined.

the same name in 1854, and especially tells of taking it from Calla lily and the Oleander. Walker, an English writer about 1849, speaking of this louse says that it feeds upon at least sixty known plants and names the potato, turnip, cabbage, lily, carnation, tulip, tobacco, peach, nectarine, and many others. Buckton, in his "Monograph of British Aphididae" in 1879, speaks of this

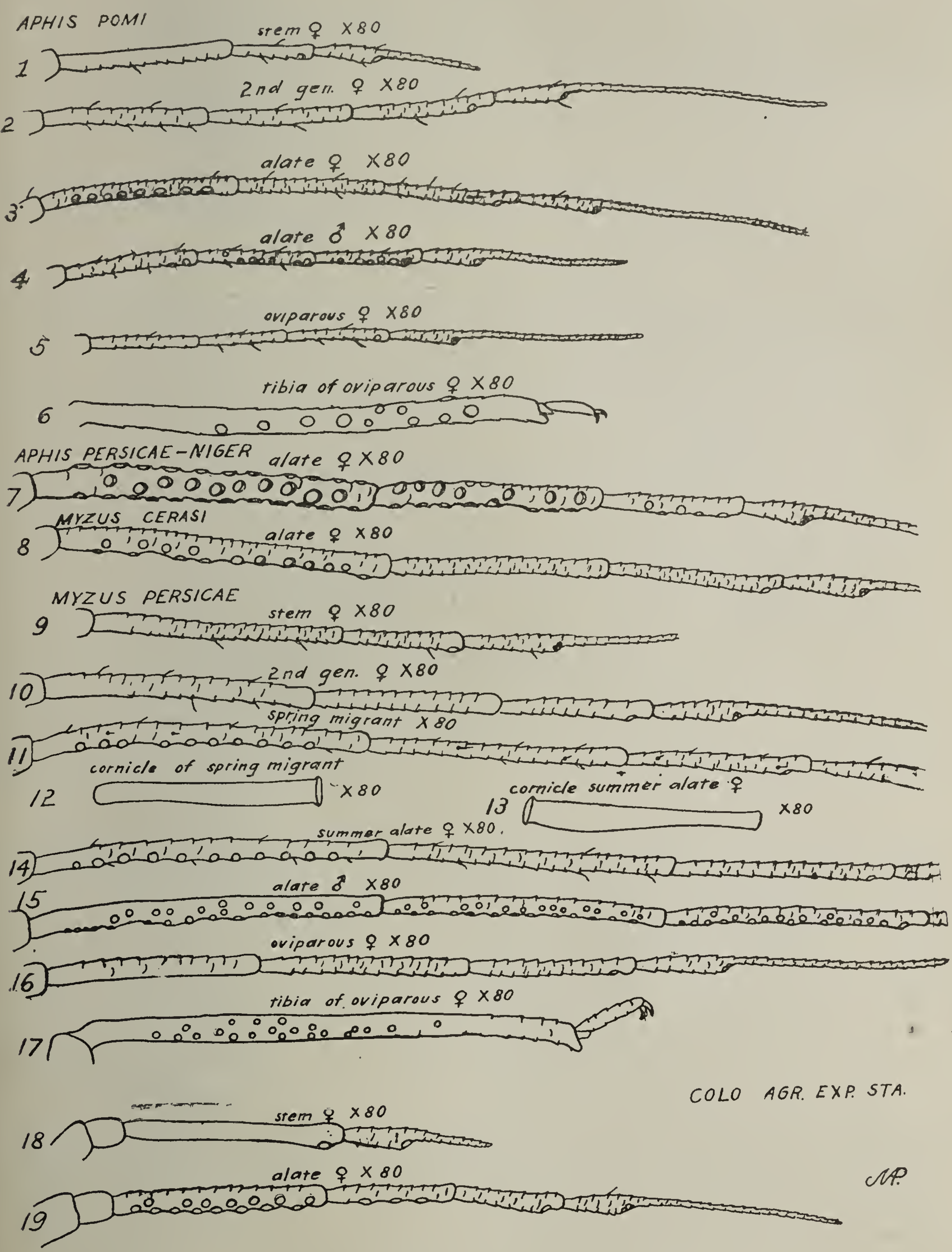

PLATE IV. Antennae, tibiae and cornicles of plant lice.
M. A. PALMER, ARTIST.

louse as being almost "polyphagus," on account of its feeding upon so many different plants.

In America this louse has also been reported under different names upon the peach, plum, cherry and man succulent plants. including several of our garden vegetables. The *Rhopalosiphum solani* of Thomas, occurring in abundance upon potatoes in Illinois; the *Siphonophora achryantes* of Monell, and the *Myzus malvae* of Oestlund* are almost certainly this *persicae* of Sulzer, which was described nearly a century and a half ago. Since arriving at the above conclusions* a letter has been received from Dr. N. Cholodkovsky of St. Petersburg, to whom specimens of this louse were sent and which were determined by him as being the *persicae* of Sulzer which he considers identical with the *dianthi of* Koch.

NAME AND LIFE HISTORY

There are two main reasons why this insect has been described under so many different names. It has a habit, which is not uncommon among the plant lice, of spending the fall, winter and spring of the year upon certain trees and shrubs, and the remainder of the year upon succulent vegetables. The winged form occurring upon the trees in the spring of the year (Plate II, Fig. 8) has its cornicles cylindrical in form while the winged individuals occurring upon succulent vegetation during the summer and fall, and those that return to the peach and other trees in September and October, (Plate II, Fig. 9) have their cornicles moderately swollen. The latter type of cornicle puts this louse into the genus *Rhopalosiphum,* while the former type of cornicle with the swollen antennal tubercles and first antennal joint, puts it into the genus *Myzus*. The other reason for the numerous names is its feeding upon a very wide range of plants.

So we are unable to avoid the rather sweeping conclusion that the green peach louse with its cylindrical cornicles, its pink egg-laying females in the fall and similarly colored stem-females in the early spring, is only the tree form of the green louse with club shaped cornicles that is so abundant in green-houses upon carnations, snapdragons, lilies, and many other flowering plants and out of doors cabbage, cauliflower, radish, turnip, potato, and a host of other vegetables, both wild and cultivated, which has been des-

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* The **Rhopalosiphum sonchi** of Oestlund, which, in "Synopsis of the Aphididae of Minnesota," he seemed inclined to give up to **Rhopalosiphum dianthi** of Shrank, is probably a good species. At least, the native **Sonchus** growing in the vicinity of Fort Collins is badly infested with a **Rhopalosiphum that** is certainly distinct from the louse here discussed, and it fits in every particular the description given by Professor Oestlund for **R. sonchi.**

* See Journal of Economic Ent., Vol. I, No. 2, p. 84.

ignated by the various names given above along with others that we have not mentioned.

This insect, then spends the winter, either as wingless lice upon succulent vegetables where there is sufficient protection to enable them to endure the cold weather, or in the egg stage upon certain trees, chiefly the peach, plum, apricot, nectarine and cherry.

The eggs are shining black in color and are deposited in the axils of the buds for the most part, but some occur in crevices of the bark. The eggs hatch very early in the spring so that the young stem-mothers (Fig. 5) from them are often almost fully grown before the earliest peach or plum blossoms open. About the time the buds begin to open upon these trees, the stem-mothers are all of a deep pink color and begin giving birth to living young. These young (Fig. 6) instead of being pink like their mothers are pale yellowish green throughout their lives, and usually there is a median and two lateral dark green stripes passing over the abdomen. Very few of this brood attain wings. The third generation become very largely winged (Fig. 8) and begin leaving the trees upon which they were born about the middle of May in the peach growing sections of the state. By the middle of June these lice have almost completely left the trees and may be found establishing their colonies upon various succulent vegetables, a list of which is given below. At this date, (Aug. 1, '08) this louse in the insectary, bred directly from specimens taken from the peach in Fort Collins, June 20, are all apterous and the body color is a uniform pale yellow without green markings.

FOOD PLANTS

The plants upon which we have found this louse establishing colonies in Colorado are as follows:

IN GREENHOUSE

Snapdragon (**Antirrhinum sp.**)
Carnation (**Dianthus sp.**)
Potato (**Solanum tuberosum**)
Radish (**Raphanus sativus**)
Alternanthera.
Calla lily (**Richardia Africana**).
Lilium candidum.
Tulip (**Tulipa sp.**)
Cauliflower (**Brassica oleracea**).
Lactuca spicata.
Turnip (**Brassica rapa**).
Tobacco (**Nicotiana Tabacum**).
Egg-plant (**Solanum Melongena**).
Amaranthus sp.
Chenopodium album.
Water Cress (**Roxipa Nasturtium**).
Asparagus fern (**Asparagus sp.**)
Nasturtium (**Tropaeolum majus**).
Red Clover (**Trifolium pratense**).
White clover (**Trifolium repens**).
Verbena sp.
Russian thistle (**Salsola tragus**).
Cotton (**Gossypium herbaceum**).
Box-elder (**Rulac negundo**).
Snowball (**Viburnum opulus**).
Apple (**Pyrus malus**).
Wheat (**Triticum sativum**).
Grass (**Poa sp.**)
Corn (**Zea sp.**)
Willow (**Salix sp.**)
Castor bean (**Ricinus communis**).
Cineraria sp.
Pot Marigold (**Calendula officinalis**).
Fetid Marigold (**Drysodia sp.**).
Digitalis purpurea.
Primula Forbesi.
Stellaria media.
Iresine lindeni (Achyranthes).
Tomato (**Lycopersicum esculentum**).

Malva sp., native.
Tansctum balsamifera.
Poppy, cultivated.
Vinca sp.
Vicia sp.
Lupine, native wild pea.
Sugar beet (**Beta vulgaris**).
Cantaloupe (**Melo sp.**)
Watermelon (**Citrullus vulgaris**).
Native thistle (**Carduus sp.**)
Chrysanthemum sp.
Marsilea vestita.
Golden glow (**Rudbeckia sp.**)
Cactus (**Opuntia sp.**)

OUT-OF-DOORS

Trees upon which eggs are laid.
Peach (**Prunus persica**).
Plum (**Prunus domestica** and **Americana**).
Choke cherry (**Prunus Virginiana**).
Prune (**Prunus domestica**).
Nectarine.
Tame cherry (**Prunus cerasus**).
Apricot (**Prunus Armeniaca**).
Sand cherry (**Prunus melanocarpa**).

SUMMER FOOD PLANTS ONLY

Cabbage (**Brassica oleracea**).
Cauliflower (**Brassica oleracea**).
Rape (**Brassica napus**).
Turnip (**Brassisca Rapa**).
Potato (**Solanum tuberosum**).
Tulips (**Tulipa sp.**)
Pansy (**Viola tricolor**).
Pigweed (**Chenopodium album**).
Radish (**Raphanus sativus**).
Amarantus sp.
Chenopodium (Bonus-Henricus.)
Malvastrum coccineum.
Wild mustard.
Lepidium sp.
Dock (**Rumex sp.**)
Bursa Bursa-pastoris.
Tomato (**Lycopersicum esculentum**).
Water cress (**Nasturtium officinale**).
Apple (**Pyrus malus**).
Pear (**Pyrus communis**).
Lilac (**Syringa vulgaris**).
Castor bean (**Ricinus communis**).
Morning glory (**Convolvulus sp.**), wild
Hollyhock (**Althaea rosca**).
Horseradish (**Nasturtium armoracca**).

Immune plants—The following plants in the insectary were not infested: onion, beognia, oxalis, (four-leaved sorrel), and coleas.

Apparently, the only reason why the above list of infested greenhouse plants is not larger is because there was not a larger list of plants growing in the greenhouse at the time. It seems that this louse will feed upon almost any tender green foliage early in the spring, or late in the fall when most plants have died out and the lice are hard pressed for food.

A plant louse like this that is able to spend the winter either upon trees in the egg stage or as a louse upon succulent vegetables that are somewhat protected from the extremes of low temperature, and with such a wide range of food plants, has a remarkable power to continue its existence in a locality where it has once been introduced.

INJURIES

When the peach trees bloom, this louse often attacks the blossoms in numbers sufficient to blight them. After the fruit forms they sometimes attack the young peaches in sufficient numbers to cause them to wilt and drop. They also attack the leaves causing them to curl and turn yellow in color and, if the attack is very severe, many of the leaves drop.

NATURAL ENEMIES

This louse is attacked by a large number of insect enemies and it is probable that its severe struggle for existence with these

foes is what accounts for its wide range of food plants and its intricate life history.

The predaceous enemies such as lady-beetles, syrphus flies and lace-wing flies are very abundant about the colonies of this insect, and at least two small internal parasites* also destroy them.

REMEDIES

About a week before the buds open, spray the trees with the ordinary strength of kerosene emulsion (one-fifteenth oil) or with Black Leaf 1 to 65 in water, or with some other good plant louse spray recommended for the green apple aphis. After the trees have blossomed, if the lice become abundant at any time, spray as for the green apple aphis.

If the peach trees are to be treated with lime-sulfur for twig borer, or brown mites before the buds open, that application should kill nearly all of the stem mothers of this louse too, if made a week or ten days before the buds open.

THE BLACK PEACH APHIS

(*Aphis persicae-niger* Smith)

Plate I, Figs. 12, 13, 14.

This louse has long been known as a pest in peach orchards in the United States where is seems to be a native insect. This seems strange, however, as the peach is a native of Asia and appears to be the only food plant for this louse. We first noted the black peach aphis in Colorado in 1905. It has not become very generally distributed in the peach orchards of the State as yet, but is known to occur in a few localities upon the western slope and at Canon City. The infested orchards are so situated, however, that it will be an easy matter in a few years for the louse to distribute itself throughout nearly all the important peach sections.

It is important, therefore, for all who grow peaches to give the closest attention to their orchards for the purpose of detecting this louse as soon as it appears and destroying it, before it becomes so widely distributed that it cannot be kept under control.

APPEARANCE OF THE INSECT

This louse differs quite widely in its habits and appearance from other species that attack the peach, and is one that any fruit grower can readily determine if he will give close attention to the characterization here given.

* A species of **Lysiphlebus** destroys large numbers, especially in greenhouses, and we have also a number of the lice killed by a very minute Chalcid (**Aphelinus** sp.), which causes the lice to turn deep shining black in color. Lice parasitized by **Lysiphlebus** become swollen and turn to a gray, or light drab color. Those killed by the Chalcid retain their natural shape. Determined for us by Dr. L. O. Howard.

While this insect is known as the Black Peach Aphis, the greater number of the individuals in any colony are always of a reddish-yellow or amber color (Plate I, Fig. 13). It is only the full grown lice that are black, whether winged or wingless, and none of the individuals are ever green in color. The fully grown wingless lice are deep shining black and highly polished (Plate I, Fig. 12.

The other lice occurring upon the peach attack the foliage and blossoms and in some cases the young peaches, but none of them attack the year-old bark of the limbs as does this one.

LIFE HISTORY

This louse appears very early in the season. Last year it was found in Delta County and also in the vicinity of Palisades, early in February in considerable numbers, and badly infested twigs were received from Paonia that were taken March 18, 1908. These early appearing lice confine their attacks to the tender bark of the twigs and are nearly always most abundant at first upon small limbs or sprouts near the ground. The tender twigs may be literally covered with the lice before the leaves open at all. When the buds do open, exposing the leaves and blossoms, some of the lice migrate upon these tender parts. They may kill the little peaches, and if at all abundant upon the leaves, the latter curl and protect the lice from storms or from the insecticides that may be thrown upon the tree by the orchardist.

The lice that appear upon the trees early in the season are all wingless. The winged examples begin to appear in the vicinity of Grand Junction about the last of April. By the tenth of May these winged lice are usually very abundant, and by the middle of May, in our experience, the lice have begun to disappear from the peach trees, and very few have been found in the orchards after the 15th of June.

It is said that this louse migrates to the roots of the peach trees where it spends the fall and winter coming back to the top early in the spring. This part of the life history we have been unable to verify although we have dug about many peach trees in search of the lice.

That it is the habit of this insect to pass the winter upon the roots of trees seems highly probable as we have been unable to find any sexual forms or eggs, and we are not aware that any one has.

In the older peach growing sections of the country this aphis has been reported as frequently killing peach trees, especially small ones in nurseries.

PREVENTION AND REMEDIES

It is not very uncommon for horticultural inspectors to find

this louse present upon the roots of nursery stock that has been shipped into the state. Undoubtedly the lice present in Colorado today, have descended from those brought to the state in this manner, and not in the egg stage.

It is a matter of much importance then, to treat all nursery stock coming to Colorado in such a way as to prevent any possibility of introducing this louse into the peach orchards upon nursery trees.

This may be done either by a thorough fumigation of the stock with hydrocyanic acid gas; or by thoroughly and forcefully spraying it with kerosene emulsion, a good quality of whale oil soap, or a tobacco decoction, before planting.

If the louse has been introduced into the orchards and is found to be present upon peach trees it is highly important that the owner keep a very close watch over his trees especially in the early spring time for the purpose of detecting the first appearance of these lice, which would probably be during the latter part of February or sometime in March in the warmer sections of the state. In the colder sections where peaches are grown to some extent, the earliest date of their appearance would probably be the latter part of March or very early in April. As indicated above, the louse may become very abundant before the buds open at all, and that is when treatment of orchards trees can be made most effective and with least expense. So far as our observations have gone, the lime-sulfur preparations have not been satisfactory for the control of this louse, but it is very readily killed by the ordinary application of soaps, tobacco preparations or oil emulsions. We would especially recommend kerosene emulsion that is 1-15 oil; "Black Leaf," 1 gallon in 65 gallons water; or home made tobacco decoction. If the treatment is made one week before the buds begin to open, the green peach aphis will also be killed by the same application.

Thorough treatment should always be made before the winged forms begin to appear, which may be as early as the middle of April.

This louse is very gregarious in habit so that it will often be the case that one or two trees, or even one side, or a few limbs upon a tree, may be quite badly attacked when no other infested trees are found in the orchard.

PLUM LICE

Besides being attacked somewhat by the green peach louse (*M. persicae*) plum and prune trees have three other species of plant lice of considerable importance in Colorado.

THE MEALY PLUM LOUSE

Hyalopterus arundinis (Fab.)

This is a light green louse that colonizes the underside of the

leaves of plum and prune trees. It often is so numerous that the under leaf surface is completely covered by the lice.

The stem-mothers hatch from black shining eggs deposited upon the twigs of the trees late in the fall. They locate upon the underside of young growing leaves where they give birth to a large number of living young which, so far as we have observed, do not acquire wings. At Austin, Colorado, May 22, '08, many of the second generation were mature and producing young. In the earlier sections this louse becomes very abundant by the 10th to the 15th of May and may continue to about the 15th or 20th of July when nearly all will have acquired wings and left the trees. About Fort Collins, at least, we find that occasional colonies of this louse remain upon plum trees throughout the summer.

Upon leaving the plum, the lice go to certain grasses to feed during the summer. We have specially found it infesting Reed-grass, *Phragmites Phragmites,* on wet ground and along ditches upon the western slope in Colorado.

About the middle of September* the fall migrants begin to return to the plum trees and to give birth to the sexual males and females. The males are winged and the females wingless. The latter deposit the eggs that remain over winter.

This louse may be easily distinguished from other plum infesting species by its light green color, with three longitudinal darker stripes above, the white powdery covering to the body, the long narrow body, the short cornicles, and the small second fork in the third sector of the fore wing. The leaves when loaded with this louse, may drop and become yellow but they do not curl as is so often the case in plant louse attacks.

REMEDIES

The lice will leave of their own accord by about July 10 in the warmer portions of the state and a little later in other sections. If found very abundant before July 1st, it will doubtless pay to make a thorough spraying with kerosene emulsion or Black Leaf as recommended for the green apple aphis.

This louse seems to have few natural enemies to keep it in check.

THE HOP PLANT LOUSE

(*Phorodon humuli* Schrank)

This is another green louse that inhabits the plum as a winter host plant. This louse is specially noted for its severe injuries to the hop during the summer months. It is generally distributed in the state and has frequently been taken by us upon both cultivated

* September 16, 1906, is our earliest date for return migrants to the plum.

and wild hops and upon plums.

At Fort Collins we have followed it upon the plum in moderate numbers throughout the entire season, and Mr. W. T. Clark* has reported it remaining upon the hop vines in California until the males and egg-laying females have been produced. So it seems probable that this louse can exist from year to year upon either of these food plants in the absence of the other.

For an excellent account of the life habits of this insect and colored figures of the different stages, see an article by C. V. Riley in Department of Agriculture Report for 1888, p. 93.

While we have not observed the stem-mothers in Colorado, we find the louse appearing during May and the early part of June upon the leaves of plum trees. Most of the lice acquire wings and leave early in July in the vicinity of Fort Collins, though on July 8, 1907, trees were seen badly infested with this louse and there were many wingless adult females still present.

APPEARANCE OF THE LICE

The wingless lice are light green or greenish yellow without noticeable markings of other colors. The winged lice have the same general body color with head, plates of the meso-thorax above, and a few dashes upon the abdomen black. All the lice are specially marked by having upon the head, at the base of each antenna, a prominent tubercle or tooth, and a less prominent one projects from the inner side of the first joint of the antenna.

About the middle of September at Fort Collins the winged return migrants begin to come from the hops and alight upon the leaves of the plum. A note made at that place October 3, '07, reads: "The winged migrants are fairly common on plum leaves now and most of them have a small colony of young surrounding them." These young develop into the wingless egg-laying females (and possibly winged males also) and a little later the eggs are deposited upon the twigs to live over winter.

REMEDIES

The same as for the green apple aphis.

THE RUSTY BROWN PLUM LOUSE

(*Aphis setariae.* Thos.)

This plum louse is readily distinguished from any of the other species mentioned in this bulletin by its dark rusty brown color together with the conspicuous white base of the antennae, entire tibiae, and tail or cauda.

This louse appears early in the season upon the bark and leaves of the tender new shoots of plum trees. We have found it

* Bull. 106, Calif. Experiment Station, 1904.

specially upon the red or Americana plums. Throughout the season it seems to have a strong tendency to cluster upon the bark of the tenderest new growth.

The louse is nearly always accompanied by ants, that attend it for the honey dew that is secreted. Usually in the colonies a few larvae of one of the small black Coccinellids (*Scymnus* sp.) can be seen. They are recognized at once by the white secretion that covers their bodies.

This louse remains upon the plum throughout the entire year. We have found it in many places east of the mountains both in the vicinity of Fort Collins and in the Arkansas Valley, but we have not taken it on the western slope. It often becomes abundant enough to be a very serious pest, but on account of its body being entirely free from any powdery secretions, it is readily treated and destroyed. From about the first of August on through the summer we have also found this louse upon barnyard grass (*Echinochloa Crus-galli.*) The louse becomes darker in color late in the season and the oviparious female in the fall is almost black. The small winged males are black in color. The egg-laying females are wingless and, in the laboratory, Mr. Bragg succeeded in getting them to lay eggs quite freely upon plum twigs, but he was unable to find any of the eggs upon infested plum trees out of doors. The lice upon plum trees during September and October were all apterous except the males, but whenever found upon barnyard grass there were many winged individuals present that seemed to be fall migrants.

Mr. J. T. Monell* reported this louse upon *Panicum proliferum*) in Missouri, and Professor O. W. Oestlund** reports it upon fox-tail (*Setaria glauca*), barnyard grass (*Echinochloa Crus-galli*) and Virginia Creeper (*Ampelopsis quinquefolia* in Minnesota.

REMEDIES

The remedies for this louse are the same as for the green apple aphis, without the early treatments for the destruction of eggs.

THE BLACK CHERRY LOUSE

(*Myzus cerasi* Fab.)

Plate II, Figs. 1, 2, 3, 4.

This is an insect that has long been known in Europe and for more than half a century, at least, has been a pest upon cultivated cherries in the eastern portion of this country. It is generally distributed through the orchards of the eastern slope of the Rocky Mountains in Colorado and has found its way into a few orchards,

* Bull. 5, U. S. Geol. Survey, p. 23, 1878.
** Aphids of Minn., p. 67, 1887.

in the valley of the Gunnison. Prompt action on the part of the orchardists where it occurs would almost exterminate it from our Western Slope.

Both the winged and wingless forms of this louse are deep shining black, the body is rather broad and flat and the cornicles are long and clyindrical. Cherry foliage may be fairly blackened by the lice before the early cherries mature.

Dr. C. M. Weed,* who studied this louse in Ohio, found winged lice appearing in great numbers about June 10 to July 1st, and all lice disappeared by the latter part of July and remained off the cherry until late in September when he began to find winged migrants again. Though no alternate food plants were found, Dr. Weed was convinced that such plants existed and that it is the instinct of the louse to entirely leave the cherry trees during the late part of the summer. We have followed this louse quite closely for two years past about Fort Collins and have found its habits about as follows:,

The lice first attract attention about the last of May upon sprouts about the trees, then upon the lower limbs, and by the middle of June may be all through the trees. About the first week in July their enemies, especially the lady-beetles, become very abundant and the lice rapidly disappear so that by the middle or latter part of the month they can only be found in scattered isolated colonies. Some of these escape their enemies and the lice gradually increase in numbers again late in August and in September, but, so far as we have observed, do not again become very numerous. At least, this louse did continue in this manner throughout the entire summer in 1907 and 1908 about Fort Collins where it was closely watched for us by both Mr. L. C. Bragg and Mr. T. D. Urbahns.

Up to about June 15th. at Fort Collins, practically no winged lice can be found and by July 1st. the great majority of the lice are either winged or pupae, and a good proportion of winged individuals continue in the colonies throughout the season.

Besides the observations of the writers, Mr. L. C. Bragg has spent a considerable portion of his time every week of the year for more than two years past inspecting plants of every kind growing in the vicinity of Fort Collins, yet this louse has never been seen by any of us upon any plant but the cultivated cherry. We are obliged to conclude, therefore, that this louse has no other regular food plant in Colorado.

REMEDIES

This louse should be treated with kerosene emulsion or one of the tobacco preparations before the winged lice appear to spread

* Bull. Ohio Experiment Station, Technical Series, Vol. I, No. 2, p. 111, 1890.

the species from tree to tree. The earlier this is done after the lice first appear the better, for then they are nearly all accumulated upon a few sprouts or limbs near the ground.

PREPARATION OF THE INSECTICIDES MENTIONED IN THIS BULLETIN.

KEROSENE EMULSIONS

The standard formula for mixing the stock solution of kerosene emulsion is as follows:

Water 1 gallon.

Tak-a-Nap, Whale-oil, or Laundry soap 1-2 pound.

Kerosene, 2 gallons.

For use, dilute with water to secure the desired percentage of oil.

For example, if a spray containing 5 per cent oil is desired, use 3 3-4 gallons of the stock solution, and dilute with water to make 50 gallons of spray. If a 6 per cent spray is desired, use4 1-2 gallons of the stock solution to make 50 gallons of spray, or if a 7 per cent spray is desired, use 5 1-4 gallons of the stock solution in making up 50 gallons, or practically 1 part stock solution to 9 parts of water. This last named strength is the one most commonly used for the destruction of plant lice upon plants while they are in foliage. Larger amounts of the stock solution may be prepared using the same ratio. If a stronger spray is to be used than those given above, it is only necessary to dilute with a smaller proportion of water, bearing in mind in computing the percentage of oil in the spray that the stock solution is two-thirds oil.

The necessary steps are: Dissolve 1-2 pound soap in 1 gallon boiling water. While boiling hot add this to 2 gallons kerosene and briskly agitate for about five minutes. A creamy mixture will be formed which, when diluted with water, will mix readily without allowing free kerosene to rise to the top. After agitating, add a small quantity of the stock solution to a bucket of clear water for trial. It should mix completely through the water, like milk. If it rises to the top as free oil, the stock solution will have to be heated again to boiling and churned until it will stand this test. To avoid accidents, the boiling solutions should be removed from the fire when it is mixed with the kerosene. An emulsion can be formed with greater ease if the oil is also warmed, but the heating of kerosene over a live fire, for safety, should only be attempted out of doors and away from all buildings. The mixture must be watched closely also to prevent its boiling over the sides of the vessel and igniting.

Mixing the emulsion is not a difficult operation. It can be done by any orchardist. The essentials of success are in having the soap suds *boiling hot* when the solutin is added to the kerosene, in

giving *immediate and thorough agitation* when the boiling soap-suds and kerosene are poured together, and in the use of clean soft water.

The apparatus may vary with the amount to be prepared. Those preparing to use several spray tanks of the material and possessing a gasoline power spray outfit find it most convenient to perform the agitation by placing the boiling hot soap-suds and the kerosene together in the spray tank and forcing the mixture through the pump. This churns the liquid thoroughly. Mr. B. A. Smith of Grand Junction, successfully prepares enough of the stock emulsion at one time in this way for five two-hundred gallon tanks of 6 per cent spray. He first dissolves in a home-made cooking vat with galvanized iron bottom and wooden sides, thirty pounds soap with thirty gallons of water, and when this is boiling hot it is poured into the spray tank upon 60 gallons of kerosene previously emptied into the tank. The gasoline engine then forces the mixture through the pump and a short spray hose back into the tank under a high pressure for several minutes until oil and soap-suds are completely combined. The whole solution, about 100 gallons, is then run off into an extra dismounted spray tank and 1-5 of the stock solution used for each 200 gallon tank, thus giving approximately 6 per cent oil in the spray. The apparatus is equipped with a mechanical agitator in the tank which operates while the emulsion is being made, but the action of these mechanical agitators will not alone form a good emulsion, and the mixture must also be pumped as described out from the tank through a spraying nozzle hose and back into the tank again.

Enough for a two hundred gallon spray tank may be made in a 50 gallon barrel fitted with a good hand barrel pump for agitation. Smaller amounts may be prepared with wash-boilers or tubs as heating vessels for the soap-suds, and to contain the oil and soap-suds when being emulsified and a good hand bucket pump will perform the agitation. If a very small quantity is to be used for a few house plants an egg beater will suffice for the agitation.

Many kinds of soap may be used to prepare the emulsion. Tak-a-Nap soap, whale-oil soap and Laundry soap have been most commonly used by the growers. The cost of the soaps should be considered. Tak-a-Nap soap is a soft soap and disolves readily. It should be heated to boiling in water when dissolved the same as other soaps insure the best results, instead of attempting to combine soap-suds and kerosene cold.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphisicide" manufactured at Grand Junction, or else use some other good contact insecticide instead.

PRECAUTIONS

When preparing and using kerosene emulsion remember:

To use soft clean water is possible.

To have the mixture as hot as possible for emulsifying.

To see that the oil, or mixture of oil and soapy water does not boil over into the fire.

To see that the oil does not separate to form a layer of kerosene on top. If this condition exists, the last of the barrel or tank will be almost sure to burn the foliage.

To remember that the strength of the emulsion depends upon the percentage of oil it contains.

To use kerosene emulsion alone, do not try to combine it with arsenical sprays.

To apply forcefully and thoroughly so as to wet the insects as it only kills by coming in actual contact with their bodies.

TOBACCO DECOCTION

Tobacco stems or tobacco dust two pounds.

Water four gallons.

Put the tobacco in the water which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simmer, but not boil,* for fully one hour, when the liquid is ready to be drained off and applied.

If the whole leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other akaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making.

BLACK LEAF

There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. If in the treatment of any louse this does not seem sufficient it may be used in the proportion of one gallon to sixty or sixty-five gallons of water. In fact, we have usually succeeded in killing plant lice with this preparation used in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or from The Kentucky Tobacco Product Co., Louisville, Kentucky.

*Dr. W. P. Headden, Station chemist, says that nicotine will be partially driven off by boiling. A distillate he prepared killed lice when diluted to 1-8 strength.

MISCIBLE OILS

There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," "Target Brand Scale Destroyer" or "Killoscale" add the oil directly to the water with a little stirring. One gallon of the miscible oil in fifty gallons of water will make a two per cent. mixture, which in most cases, should be strong enough to kill plant lice if thoroughly applied.

LIME-SULPHUR MIXTURE (FOR WINTER SPRAY ONLY)

FLOWERS OF SULFUR, FIFTEEN POUNDS

Good lump lime, fifteen pounds. Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot, add the sulfur and stir it in. Place over the fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained through gunny sacking to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime-sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

REX LIME-SULFUR

We have found the Rex lime-sulfur in the proportion one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime sulfur preparation.

WHALE-OIL OR FISH-OIL SOAPS

The so-called Whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six or eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used successfully are Good's Whale Oil Soap and Bowker's Tree Soap.

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Orchard Plant Lice

AND

Their Remedies

BY

C. P. GILLETTE
E. P. TAYLOR

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ORCHARD PLANT LICE AND THEIR REMEDIES.*

C. P. GILLETTE AND E. P. TAYLOR.

The plant lice that are commonly designated as "aphids" have very similar habits, structures, and remedies. These should be known and understood by the farmer and fruit grower who have to contend with them. Nearly all of these lice are rather easily destroyed when proper remedies are intelligently applied to them. Probably the plant lice here mentioned are the most serious orchard pests in Colorado at the present time.

GENERAL STRUCTURE AND HABITS.

All of the plant lice get their food by inserting a beak and sucking the sap of the plant. They never eat away the tissue of the leaf.

Throughout the entire summer, from spring to about the first of September, all of our plant lice that infest orchard trees, increase in numbers by giving birth to living young. If eggs are laid at all they are deposited by the last brood of females in the fall. From the fact that a single louse is usually able to give birth to from 75 to 150 young, and as they mature in about eight to ten days after being born, it will readily be seen that the plant lice are capable of increasing with wonderful rapidity. This accounts for the fact that the lice may nearly all be killed from a tree and that tree be very seriously infested with the lice again within a few weeks. Usually the last brood in the fall are about one half males and one half females. These females deposit the eggs that live over winter and the lice all die. We have an exception of this rule, however, in case of the woolly apple aphis which lives over winter as young or partly grown lice upon the trunk and branches, and in all stages of growth upon the roots of the trees.

Plant louse eggs usually hatch in the spring a little before the leaf buds begin to open on the trees that they infest. These early lice hatching from the eggs are always wingless in the species mentioned in this bulletin, and are called stem-mothers. These stem-mothers mature in a short time, are all females, and begin giving birth to young lice which constitute the second brood. It is seldom that the second brood of lice have more than a very few winged ones. The remainder of the life history of these lice will be given under the different species treated.

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*This bulletin is an abbreviated edition of Bulletin 133, "A Few Orchard Plant Lice," by C. P. Gillette and E. P. Taylor, and is prepared to give the most important information needed by fruit growers. Bulletin 133 gives a much fuller account of the plant lice, and is illustrated by colored plates of some of the most important species. The technical matter, and that which does not relate to the economical side is omitted from this edition, which is intended to meet the needs of most people.

Bulletin 133 will be sent on request made to the Director.

ANTS AND HONEY DEW

Wherever the aphids are abundant, it is usually true that ants may be seen running over the infested tree or plant. It is often thought by the orchardist or farmer that the ants are present to destroy the lice, but this is probably never the case. Nearly all plant lice excrete from their bodies a sweet liquid known as "honey dew." This liquid, gathering upon the leaves of the plants, cause them to be shiny and sticky as if they had been varnished. The ants are very fond of this liquid and visit the lice to obtain it, and are always very careful not to injure the plant lice themselves.

NATURAL REMEDIES

The plant lice are greatly lessened in numbers every year by insect enemies. Most important among these are the "lady-beetles," the "syrphus flies," and the "lace-wing flies" or "aphis-lions." Wherever these are found upon the infested plants they should be carefully protected as they often destroy the lice so completely that it is not necessary to make any application to kill the lice artificially.

REMEDIES

The most common remedies for the destruction of plant lice are kerosene emulsion, tobacco decoctions, or soapy preparations. An insecticide that will destroy one plant louse will usually be effectual in destroying any other, if a thorough application is made.

Plant lice fly so freely from one orchard to another that it is very important that all of the orchardists in a community spray their trees whenever the lice are abundant. If one man should fail to do this, the plant lice leaving his trees, would in nearly every case, be sufficient to thoroughly colonize all of the orchards near him. Co-operation then is very important in any campaign against plant lice.

APPLE PLANT LICE.

WOOLLY APPLE APHIS. (*Schizoneura lanigera Hausm.*)

This is probably the most serious apple pest in Colorado. It is a bark feeder, and it attacks both the roots, the trunk and the limbs of the trees, but does not feed upon the fruit or foliage. This louse is readily recognized on account of its being covered with a white woolly secretion which has suggested its common name. Upon the trunk and branches the lice attack either the tender bark about the scars or the bark of tender new shoots. Below ground, the lice attack the bark of the smaller roots causing warty swellings upon them. If very abundant, the roots are often completely covered with these smooth wart-like growths which sometimes cause the roots to die and rot off. When very abundant upon the very rapidly growing twigs, these lice often produce abrupt swellings due to the thickening of the inner bark. Sometimes these swollen portions of the limbs crack open lengthwise and the limbs may be sufficiently injured to case them to die. Severest injury is done to the tops where there is the tenderest and most rapid growth as in grafts and water sprouts.

LIFE HABITS

The life habits of this insect may be briefly stated as follows: Early in the spring there will be a few living lice in protected places beneath the bark or under the dead bodies of the lice that were killed the previous fall, There will also be a large number of lice living over upon the roots of the tree beneath the surface of the ground. The lice that live over on top are all very small. Those living over upon the roots are of all sizes from the smallest to those that are fully grown. By the time that the buds begin to open in the spring, the lice that live over on top will locate on tender new bark and insert their beaks and begin to suck the sap of the tree and to grow in size. At the same time a greater or less number of small lice that live over winter about the crown of the trees, and perhaps some that came up from the roots, migrate to the top and begin to feed and grow. These lice start the round of development for the year on the tree tops. They are usually first detected by the fruit grower when the little lice have grown enough to secrete a white covering to their bodies which makes them appear like little mouldy spots upon the bark. These lice increase very rapidly in number so that by the middle of June or first of July the tree may be very badly infested and the cottony secretion may be so heavy as to hang down and even fall from the bodies of the lice.

The lice are all wingless until about the first of September when an occasional wigned louse may usually be found upon the trees. These lice leave the trees where they develop and fiy to others. Each of these winged lice gives birth to about four or five males and as many females. Before winter comes on, each female deposits a single egg and dies. No one seems to have followed this part of the life history of the woolly aphis in the orchard. It is supposed that these eggs hatch the following spring and start new colonies.

Upon the roots of the trees the woolly aphis lives in large numbers the year around, the only difference in the winter being that the lice reproduce very slowly, so do not increase much in numbers. The cold weather seems never to be sufficient to kill them even in our coldest climates where the apple is grown.

PREVENTION

Prevention is nearly always better than the cure. Great care should be taken therefore, when setting out a new orchard, to prevent the introduction of this louse. Orchards are usually infested by the lice that are upon the roots of the nursery trees when they are set out. All nursery stock should be thoroughly disinfected either by fumigation with hydrocyanic acid gas, or by very thorough spraying of the trees, both roots and branches, before they are set, with one of the remedies mentioned below for spraying tops.

One method of preventing injuries from this louse is to have all apple trees upon Northern Spy roots, as Northern Spy seems never to be seriously attacked by this insect.

If nursery stock is received with roots "puddled," covered with mud, the purchaser should insist upon this mud being thoroughly washed off, and the roots treated for woolly aphis, as this is one of the methods that the nursey man has of covering up woolly aphis upon his nursery stock.

To prevent the spread of the woolly aphis from tree to tree and orchard to orchard, the lice should be well cleaned out of the orchard before the first week of September as it is about this time when the winged lice begin to fly about to spread the species.

REMEDIES ABOVE GROUND

Wherever this louse can be reached by sprays it may be destroyed like other plant lice, but one precaution is necessary, the spray must be applied with sufficient force to remove or penetrate the wooly covering. There are several spray materials that we have found entirely successful when thoroughly applied to this insect.

Kerosene Emulsion—According to our experience, a good kerosene emulsion has no superior for the destruction of this insect. It seems to penetrate the woolly covering rather better than most other insecticides. When used in the ordinary strength (1/15 oil) we have always found it efficient. In the proportion of one-twentieth oil (5%), we have usually found it sufficiently strong if applied with a good deal of force and thoroughness.

Directions for preparing kerosene emulsion are given on a later page.

To be most successful, apply as a moderately coarse spray and with a pressure, if possible, of one hundred forty to one hundred eighty pounds.

Scalecide and Other Miscible Oils—There are upon the market a number of so-called miscible oils which, when put into water, break up at once into very fine particles forming a milky white emulsion. These oils we have found fairly successful. Two to three gallons are used in each one hundred gallons of water. After being prepared, if these oils separate out so as to form an oily film upon the surface of the water, they should not be used.

Soaps—We have found the standard whale-oil soaps such as "Good's Whale Oil Soap" and "Bowker's Tree Soap" quite effectual for the destruction of this louse when used in the proportion of one pound of soap to each six or eight gallons of water.

Black Leaf—The Kentucky Tobacco Product Co., of Louisville, Kentucky, manufacture a tobacco extract which they sell under the above trade name and which has become very popular among the orchardists of Delta County, Colorado, as a spray for orchard plant lice. We have tested it quite thoroughly and have found it very efficient for the woolly aphis if used in the proportion of one gallon of the Black Leaf in sixty-five to seventy gallons of water. In fact, we have usually been successful when using Black Leaf as weak as one gallon to one hundred gallons of water. This strength, however, requires very thorough application. It would be a good plan for any one to treat a few trees with varying strengths of this or any other insecticide for the destruction of lice a day or two before taking up his general spraying work, for the purpose of determining whether or not the strength that he contemplates using is sufficient to kill the lice. In this way he may save many dollars, from using the insecticides in a strength that will not do the work or in a proportion unnecessarily strong.

Tobacco Decoction—If any prefer to make their own tobacco decoctions, they may use tobacco stems or tobacco dust or whole-leaf to-

bacco. Fruit men, however, have not reported very uniform results from their own preparations. This may be due to adulterations in the tobacco or from different methods of preparing the decoction. For the preparation of tobacco decoctions see under Preparation of Insecticides, below.

It might be advisable for one who has very much spraying to do to grow his own tobacco. Mr. W. S. Coburn, President of the Colorado State Board of Horticulture, tells us that he has had excellent success using tobacco of his own raising. He uses the whole leaf and makes a decoction using one pound of tobacco for each six gallons of water. The tobacco is steeped for at least one hour, and then applied warm.

Lime-Sulfur Sprays—The lime-sulfur sprays have not been successful in destroying the woolly aphis during the summer season when the body is covered with the woolly secretion. It has been fairly successful when applied two or three weeks before the buds open for the destruction of the little lice that live over winter upon the trees and which do not have their bodies protected by the secretion.

LATE WINTER OR EARLY SPRING APPLICATIONS

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were also largely freed from the woolly aphis. The insecticides that were found successful in the destruction of these little over-winter lice were:

Lime 15 pounds, sulfur 15 pounds, water 30 gallons.
Lime 15 pounds, sulfur 15 pounds, water 45 gallons.
Rex lime-sulfur 1 gal., water 7 gal., lump lime 2 lbs.

Lime 15 pounds, sulfur 15 pounds and water 60 gallons was a little weak and did not give results that were fully satisfactory, and the same was true of Rex 1 gallon, water 7 gallons, without the addition of lime.

We have no doubt but what the kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps mentioned above could also be used successfully as early spring sprays for the destruction of the over-winter lice upon the tree tops, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then as a final act for best results, put Tanglefoot bands about the trunks of the

trees so that the lice at the roots can not migrate to the top. For the application of these bands see next paragraph.

TANGLEFOOT BANDS

In the experiments upon the Western Slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan and is the sticky material put upon the Tanglefoot Fly-Paper. When at all abundant upon the trees, the newly born lice are much inclined to travel about and it is often astonish to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Apparently these bands do no harm to trees, but what their effect might be when continued for years we are unable to say.* In most instances we have put them directly upon the bark but it would be safer, so far as any possible injury to the tree is concerned, to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band. in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree but they get down to them directly from the surface above. So far as possible, the descending over-winter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration both to and from the roots can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compact after a rain or an irrigation.

TRIMMINGS

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths. A thorough thinning of the top so that plenty of sunlight can enter has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

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*Mr. Geo. P. Weldon, reports, from recent observations upon the Western Slope in Colorado, rather severe injuries from the application of Tanglefoot bands that have been directly upon the bark for a year or more.

TREATMENT BELOW GROUND

The treatment below ground is all aimed at the lice that are within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below ground if they can only be put in contact with the lice, and then the orchardist should be cautious not to accumulate in the soil about the crowns of his trees substances that are likely either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given below.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following The materials used upon the roots were Kerosene Emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, whale-oil soap, and carbon bisulfid.

Before making the applications the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins which varied some in depth and diameter with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. And when the liquid had nearly or quite soaked into the ground the basin was filled again and the earth banked well about the trees. In hard compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil, and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3% to 50%), killed the lice well when the roots had been well treated. Where less than 6% of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where, 7, 10, and 15% of oil was used the effect was still more lasting; and the 20, 33 and 50% treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

A later examination was made by Mr. George P. Weldon, 1908. Mr. Weldon found the woolly aphis about equally abundant upon the treated and untreated trees in all of the blocks. Even those that were treated with 50% kerosene emulsion were badly infested upon the roots at the time that he made his examination. So we have to conclude that any treatment for the destruction of the woolly aphis upon the roots is only of temporary value. But the stronger preparations do repel the lice for a short period of time, perhaps two or three months. Mr. Weldon also found that where the 50% emulsion was used the trees appeared to be seriously affected and

probably would not live through another year. None of the weaker preparations seem to have done any injury to the trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7% kerosene emulsion, a 1 to 60 Black Leaf Dip (or some other strong tobacco decoction), or a good whale-oil soap, 1-lb to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree at the same time. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7% emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10% kerosene emulsion, Black Leaf Dip (1 to 50), 2 to 3 gallons to a tree, or if the soil is quite open and porous, carbon bisulfid.*

CARBON BISULFID

This insecticide has often been reported successful against this insect.

A splendid opportunity was afforded to observe its results in the 20 acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks from this date.

A shovel was thrust deeply into the ground about 18 inches to two feet from the base of the tree with the blade broadcast to the tree. The handle was then tipped forward and the carbon bisulfid poured into the bottom and at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. The liquid was not poured directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as three cents per tree.

TOBACCO DUST AND STEMS

Dry tobacco in the form of tobacco dust or tobacco stems or even the whole leaf tobacco when used freely about the trees has not given very satisfactory results. Apparently these substances are of no use unless the tobacco is thoroughly wet, as soon as it has been placed about the roots, so that the juices will penetrate the soil and kill the lice. In a few instances orchardists have reported very satisfactory results but in nearly all cases they have reported failure. We believe if tobacco is used at all against this insect upon the roots of trees the best method is to apply it in the form of a strong decoction.

Prepare as for a top spray and use two or three gallons about each tree as in case of kerosene emulsion as described above. The tobacco does not have as lasting an effect apparently as does the emulsion.

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*Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

Tobacco decoction in which two pounds of stems, or dust, or one pound of whole leaf tobacco was used to each three gallons of water and forcefully sprayed upon the exposed roots gave fairly good results but these were not equal in their killing and repelling effects to a 10 to 15% kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well but had very little repelling effect afterwards.

Lump Lime applied in a manner similar to that employed with the tobacco stems, 10 to 20 pounds to a tree, was of little or no benefit.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were, "Chloroleum" potash lye, wood ashes, salt, and flooding with water for several hours.

THE GREEN APPLE APHIS. (*Aphis pomi DeGeer.*)

This is the common green louse curling the leaves of the apple tree in Colorado. While primarially a leaf feeder this louse also attacks the tender tips of growing shoots, especially grafts and water sprouts. This insect ranks close to the woolly aphis in extent of injuries to the apple trees. It also attacks the pear, the thorn and the quince quite freely.

LIFE HISTORY

This louse remains upon the apple, or closely allied trees, throughout the year and does not go upon other trees or vegetables.

The first lice in the spring hatch from eggs that were deposited the previous fall upon the twigs of the trees. These first lice hatch a few days before the buds open and are ready to insert their sharp beaks into the first tender green tissue of the opening buds. These lice are all females and become fully grown in about two or three weeks, when they begin giving birth to living young. From this time on the lice increase very rapidly if they are not kept down by their natural enemies or the insecticides of the orchardist.

At first all the lice are wingless, but by the 10th to the 15th of May in the warmer portions of the state, and about two weeks later in the cooler orchard sections, the winged lice begin to appear and to fly from tree to tree and orchard to orchard with the prevailing winds. About the first week in September little brown wingless males and green wingless egg-laying females will appear, and a little later the females will begin laying green eggs that soon turn black upon the apple twigs. The freezing nights in November or early December kill all the lice and the eggs live over to hatch the following spring.

REMEDIES

Treatment for this insect may be for the destruction of the eggs and young lice before the buds open in the spring, or for the destruction of the lice upon the leaves during the growing season.

TO DESTROY THE EGGS

Kerosene Emulsion in all our experiments has proven useless

for the destruction of the eggs except when applied so strong as to make it entirely impractical to use it.

The Lime-Sulfur Mixtures—Either the 1-1-2, or the 1-1-3 formula or Rex lime-sulfur in dilutions down to 1 gallon in 8 gallons of water, have given good results. Lime-sulfur by the 1-1-4 formula is a little weak for good results.

Black Leaf—This preparation used in the proportion of 1 gallon in 25, and 1 gallon in 33 of water gave good results, but 1 gallon in 40 gallons of water was not very satisfactory, many of the eggs hatching.

SUMMER SPRAYING

For the destruction of the lice upon the leaves spray very thoroughly and forcefully from all directions with kerosene emulsion, 5 to 7 per cent. oil; Black Leaf, 1 part in 70 parts of water; or one of the other plant louse sprays discussed at the close of this bulletin, remembering that **thorough and forceful applications** are necessary in order to get best results.

PEACH PLANT LICE.

There are two species of plant lice attacking peach trees in Colorado, the Green Peach Aphis (*Myzus persicae Sulz.*) and the Black Peach Aphis (*Aphis persicae-niger Smith.*) The former is very generally distributed and occurs nearly every where that this fruit is grown, while the latter occurs in isolated orchards only, and might be kept down so as to do no appreciable harm, and it is quite possible that it might be practical to exterminate it from the state.

THE GREEN PEACH APHIS

Is distinguished by its pale green, or greenish yellow color in the wingless forms and the winged lice have the same general ground color to their bodies with more or less of black markings above.

The lice appear very early in the spring and often attack the blossoms, and the young peaches when the latter first form, causing them to wilt and drop. Later it attacks the leaves causing them to curl and turn yellow. By the middle of the summer this louse leaves the peach trees and goes to cabbages, turnips, radishes, tomatoes, potatoes and many other growing crops, as well as many of the common weeds. The lice remain upon these plants during the summer and in the fall there are winged forms that return to the peach to give birth to true males and females, the latter of which deposit the eggs that remain upon the twigs of the trees during winter to hatch out the early lice of the following spring.

REMEDIES

Spray thoroughly with kerosene emulsion, Black Leaf (1 part in 60 of water), or a solution of whale-oil soap (1 pound to 6 gallons of water), about three or four days before the blossoms open. Then, if the lice appear later, treat as in case of the green apple aphis.

THE BLACK PEACH APHIS

This louse is readily distinguished from any other attacking the peach

by its black color when fully grown, whether winged or wingless. The immature lice are of a yellow or amber color. In all stages, and especially in the spring, this louse will be found upon the bark of the small limbs where it continues to feed after the leaves appear. Many of the lice will go upon the leaves also causing them to curl.

Like the preceding species, this louse also disappears by the middle of July or the first of August without anything being done for it, but it does not go to any other plants so far as known, but is said to descend to the roots of the peach where it remains until the following spring. So far as known this species does not lay eggs but lives over winter as a louse.

This insect is continually being shipped into Colorado upon the roots of nursery stock. Our Horticultural law and the vigilence of our county horticultural inspectors has done much to keep it out of the orchards, but it is impossible, under present methods, to prevent an occasional tree, infested with this louse, being planted.

REMEDIES

All peach trees, before being planted, should be thoroughly fumigated, or dipped or sprayed with Black Leaf, a home-made tobacco decoction, or a good kerosene emulsion.

The remedies in the orchard are the same as for the Green Peach Aphis mentioned above.

PLUM PLANT LICE.

THE MEALY PLUM LOUSE. (*Hyalopterus arundinis Fab.*)

A light green louse with a rather long narrow body that is covered with a fine white powder. The lice occur upon the under side of the leaves, which they may completely cover by the middle of June, but the leaves do not curl. By the first week in July, many of the lice are winged, and by the last of that month the lice will nearly all have left the plum. The lice go to certain grasses, especially the large coarse Reed-grass growing in wet places. In the fall winged migrants return to the plum where, later, the eggs are deposited by egg-laying females and the lice all die. The next spring the eggs hatch to continue the species.

REMEDIES

Spray as for the green peach aphis but use a heavy pressure and direct all of the spray upon the under side of the leaves where all the lice are. These lice are killed with difficulty on account of the powdery covering upon their bodies.

THE RUSTY PLUM LOUSE. (*Aphis setariae Thos.*)

This louse is readily distinguished from all others upon the plum by its dark brown body color, and with a hand lens one can usually see the concpicuous white legs, antennae and tail. This louse seems to have a preference for the tender bark near the tips of rapidly growing shoots although it covers the undersides of the leaves also. At a little distance the louse may almost appear black to the naked eye. This louse spends the entire

year upon the plum, though it is known to attack barn grass **Echinochloa Crus-galli.**

The remedies for this louse are exactly the same as for the green peach aphis already mentioned.

THE BLACK CHERRY LOUSE. (*Myzus cerasi Fab.*)

This louse has long been known in Europe as a pest upon cherry trees. It is generally distributed throughout the cherry growing districts of the eastern slope in Colorado, but as yet only occurs in isolated orchards upon the western slope.

Those having cherry trees should make a vigorous attempt to exterminate this louse as soon as it is noticed in the cherry orchards. It could not be mistaken for any other insect upon the cherry tree as it is deep black in color and infests the under side of the leaves and the bark of the tender new growth. It is usually accompanied by ants in abundance. This insect remains upon the cherry, and so far as known, does not migrate to any other plant. On account of its numerous insect enemies it is likely to almost disappear for a time during the middle of the summer, but may continue quite abundant thoroughout the season. The last brood in the fall lay eggs which carry the species over winter to hatch in the spring.

The remedies are exactly the same as for the foregoing species.

THE HOP PLANT LOUSE. (*Phorodon humuli.*)

This is the green louse that has caused such severe losses in hop vineyards. The hop is the summer food-plant and in the fall winged hop lice migrate to the plum trees where the egg-laying females later deposite eggs upon the branches which hatch the following spring. These lice are very similar to the preceding in general appearance but lack the heavy covering of powder. While most of the lice leave the trees for the hop before the middle of July, we have found some of the lice remaining throughout the summer on plum leaves.

REMEDIES

The same as for the green peach aphis.

PREPARATION OF A FEW IMPORTANT PLANT LOUSE INSECTICIDES

Kerosene Emulsion—Prepare in the following proportions:

Soap one half pound.
Water one gallon.
Kerosene two gallons.

To prepare, dissolve one half pound of soap in one gallon of soft water by boiling; when well dissolved and still boiling hot, remove from the fire and add two gallons of kerosene, and agitate at once as briskly as possible. If large quantities are being made, a good way to emulsify is to use a force pump and spraying nozzel and pump the mixture as forcefully as possible back into the vessel containing it. If the emulsion is properly formed, the whole mass will appear much like whipped cream and will mix readilly in water without a film of oil rising to the top. Sometimes, when

the oil is rather cold, it lowers the temperature so much that a good emulsion is not obtained. In this case the dish may be placed back over the fire and the mixture heated to the boiling point when it must be again removed and agitated to form the emulsion. In case the mixture of soapy water and kerosene is placed over the fire, it must be watched every moment to see that it does not quickly boil over and take fire. As soon as emulsified, add twenty-seven gallons of water and use at once. This will make thirty gallons of the mixture, and such an emulsion will be one-fifteenth oil (or a 7% emulsion). This is the strength ordinarily used for the destruction of insects upon plants. For larger or smaller quantities, prepare in the same proportions.

Sometimes the emulsion is not perfect and a little oil rises to the top. In such cases, if the last in the barrel or tank is pumped out upon the foliage, it is likely to burn it. So it is advisable, unless the emulsion is of good quality, to throw out the last few gallons making no use of it.

It is best to dilute and apply kerosene emulsion as soon as it is prepared.

Avoid using alkali or any hard water in making the emulsion, as it will cause the oil to separate and rise to the top. Any clean soft water will usually give good results.

If a stronger emulsion is to be used, prepare as above, but do not use as much water in making the dilution. For example, if 17 gallons of water were added in place of 27 to dilute the emulsion, it would be one-tenth oil or a ten per cent. emulsion, and if 37 gallons were added, it would be a five per cent. emulsion.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphiscide" manufactured at Grand Junction, or else use one of the tobacco preparations instead.

Tobacco Decoction—

Tobacco stems or tobacco dust two pounds.

Water four gallons.

Put the tobacco in the water, enought to cover, which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simply simmer for fully one hour, when the liquid is ready to be drained off, diluted to the above proportions and applied.*

If whole-leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other alkaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making if possible.

Black Leaf—There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. But if in the treatment of any louse this does not seem sufficient it may be used in proportion

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*Dr. W. P. Headden, Chemist of the Experiment Station, has proven that the nicotine is rapidly driven off by boiling, and especially where the water is strongly alkaline.

of one gallon to sixty or sixty-five gallons of water. We have usually succeeded in killing plant lice with this preparation in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or The Kentucky Tobacco Product Co., Louisville, Kentucky.

Miscible Oils—There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," or "Target Brand Scale Destroyer" or "Killoscale," add the oil directly to the water with a little stirring. One gallon of the miscible oil in 30 to 50 gallons of water will make a mixture, which in most cases will be strong enough to kill plant lice, if thoroughly applied.

Lime-Sulfur Mixture—(For winter spray only.)

Flowers of sulfur, fifteen pounds.
Good lump lime, fifteen pounds.
Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot add the sulfur and stir it in. Place over fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime-sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

Rex Lime-Sulfur—We have found the Rex lime-sulfur in the proportion of one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime-sulfur preparation. Rex lime-sulfur solution can be made white by the addition of lime at the rate of 5 to 10 pounds for each 50 gallons of spray.

Whale-Oil or Fish-Oil Soaps—The so-called whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice, will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six to eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used quite successfully are Good's Whale-Oil Soap and Bowker's Tree Soap.

Bulletin 135 December 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE AUSTRALIAN SALTBUSH

Its Composition and Digestibility

NOTES ON RUSSIAN THISTLE

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
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The Agricultural Experiment Station

FORT COLLINS, COLORADO

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AUSTRALIAN SALTBUSH (*Atriplex semibaccata*)

ITS COMPOSITION AND DIGESTIBILITY

NOTES ON RUSSIAN THISTLE

By WM. P. HEADDEN

The California Experiment Station received the seed of this saltbush from Baron Von Mueller in 1888. In 1899, Charles H. Shinn, in Bulletin 125, states as the result of eighteen years' experimentation with saltbushes at that station, "that the *Atriplex semibaccata,* is the most generally useful species of all that have been planted, although others are worthy of cultivation."

Very favorable reports concerning the value of this plant gained currency, and it seemed that it might be of value to Colorado, as it would furnish a desirable fodder for the stock in the eastern part of the State, where the rainfall is sometimes insufficient for the production of good corps of other forage plants. This view was entertained by the writer previous to the appearance of the bulletin above referred to and seemed to be confirmed by the facts set forth therein. A small quantity of seed was procured in the spring of 1900 and planted on land previously used for experiments with sugar beets. The seeds were drilled in very shallow, but still too deep according to subsequent experience and a very poor stand was obtained—except in spots, where the plants were too thick.

The growth of the plants was entirely satisfactory, some of them attaining a diameter of seven feet and they bore an abundance of seed. I left the plot till the next spring, hoping to learn whether the seed would germinate and furnish me plants enough for the work of the ensuing year. In the meantime, however, a change had been made in the chair of agriculture and the new incumbent, knowing nothing about my work, plowed up my plot. This will explain why some of the statements in this account of the plant in Colorado are based on a garden experiment.

So far as the general culture of the plant is concerned the only question that presents any trouble is in getting it established; when once established it will seed itself abundantly. The best way to obtain a stand of this plant, in the beginning at least, is by transplanting; one can, of course, drill the seed. If this is done, the drills should be at least eight feet apart. The young plants, if well hardened and stocky, will need a little water when first set out to start them well, but when once established they will stand neglect, drought, and more abuse than most plants.

The seed, if they are plump, and fairly fresh, will germinate freely, but will rot if covered deeply. If they are sown in boxes, it is best to firm them and scarcely cover them at all. Good results

may be obtained by simply firming the seed on the soil and covering for a day or two with a thin cloth of any sort which can be kept moist. A similar observation concerning the depth of sowing is made by the California Station in Bulletin 125.

The first season's experience with this plant was on a poorly drained, alkali soil, and while for reasons already given, the experiment was not as satisfactory as one might wish, the results sufficed to show that the plant will do well under such conditions and furnish a large amount of fodder. Some of the single plants attained a diameter of seven feet. The garden experiment was in the main more successful, though less attention was paid to it. The plants seeded heavily and were not gathered, but left where they grew. They proved to be easily killed by freezing—it is stated in the California bulletin that the plants will endure a temperature of 14° F. below the freezing point.

My plants in the garden plot all perished during the winter, but the seed came up very freely the following spring, and this little plantation maintained itself for the next five seasons with but little care and without other water than our usual rainfall.

The California station made observations on the amount of rainfall necessary for this plant to make some growth, not a luxuriant growth whereby single plants attain a diameter of twelve or more feet, but sufficient when planted in rows two feet apart to cover the ground. They state that "one-fifth of an acre, sown in December, yielded 100 pounds of seed. This plot was cut in September and, cured for fodder, yielded at the rate of five and one-half tons of hay per acre. Three such cuttings were practicable on this light, granitic, sandy loam, underlaid by hard pan, during the driest season known." The rainfall for this season, 1897-'98, is given as 4.75 inches. The plant makes a remarkable growth with a very small supply of water. The writer of the bulletin referred to states further that, "on unirrigated land there was no green fodder-plant excepting saltbush (*A. semibaccata*), in the entire region." The rainfall during the seasons that the plant grew in my garden without irrigation was not noted, and while it was certainly larger than this recorded at one of the California sub-stations, it was not sufficient for the growth of our ordinary grasses.

This plant grows on the ground, not erect like alfalfa, but spreads out into a circular mass varying in diameter. Well-grown individual plants in our plot attained a diameter of seven feet, but single plants are recorded as having attained, in California, a diameter of even eighteen feet. The stems are slender and leafy.

The habit of the plant makes it hard to cut, and the leaves are easily lost in making hay—this plant is, of course, not to be considered as a forage plant where alfalfa can be grown—but its drought

resisting power may make it worthy of consideration by some people in this State. In our eastern counties, I have seen Russian thistle hay and have been informed that it was highly prized. I took this statement *cum grono salis* because the hay did not look to me as though it were fit to be eaten by any kind of stock and I saw no proof that the stock liked it. Mr. Payne, of Akron, suggests that Russian thistle hay may have a place in the feed of the plains stock as a laxative, for constipation is not uncommon among them. The Russian thistle is used to a limited extent in other parts of the State for hay making, and inquiry elicited from a thrifty, energetic ranchman the information that he had found it entirely unsatisfactory. Further, I have known the saltbush, *A. argentea*, to have been made into hay not for constant use, but as an emergency fodder for periods when the stock could not obtain enough to eat, or indeed anything by grazing. In sections where forage plants are such a desideratum as in these just referred to, any plant having better qualities than the indigenous ones or such as have been imported would be a blessing. This is really the reason for presenting this bulletin, for in this Australian saltbush, *A. semibaccata,* we have a plant which will reproduce itself freely from seed; the little plants will bear transplanting quite well; it will resist drought after it is well rooted and produce an amount of hay greater than the thistle now occasionally used, and of certainly as good or a better quality. In the sections of the country to which reference has been made small crops of sorghum can be grown, not always enough to be called a crop, but sometimes a fair one. This sorghum is not, especially in the spring of the year, a good fodder. It has no spines, as the thistle hay has, but sheep fed on it—sorghum fodder—lost weight rapidly. I know nothing about either the yield or quality of milo maize, but as compared with the other fodders mentioned, the Australian saltbush hay, though not presenting an attractive appearance, is worthy of consideration and that not as a portion of a ration but as a fodder to be given alone, for the question presenting itself to those persons in Colorado who may find it to their advantage to grow this as a forage plant, will in all probability be, not what they may mix to produce an advantageous ration, but simply as to what they can obtain to feed. The fact that they have used the so-called sand grass of the plains, Russian thistle, sunflower, and the native saltbush, *Atriplex argentea,* for the purpose of hay making indicates clearly that anything as good or better than the best of these, which they can grow, is at least a desirable thing for them.

The study of this plant had another object in view, or perhaps it is more nearly correct to state that in the beginning the object was to study its merits as a fodder and its adaptability to Colorado conditions, but in the end the object was extended to what we may

more properly designate as a chemical study of the fodder. It was advisable then from either standpoint to study the effects of the hay when fed alone, and it is not intended that any statement made shall be construed as indicating that hay made from this plant might not give more satisfactory results than will be presented in this bulletin if properly mixed with some other fodder but, as already stated, the conditions under which it would have to be fed have alone been considered.

So far as the readiness with which this saltbush can be grown is concerned and its ability to make a good growth with a small supply of water it commends itself. The other questions pertaining to it may be succinctly stated in a few words, does it present difficulties in cutting and being made into hay, will animals eat it readily and do they do well on it, *i. e.*, does it furnish sufficient nourishment to maintain or perhaps fatten the animals?

Under our conditions the plant is an annual which forms a spreading mass of growth on the ground, unless planted very thick, as it is apt to be in the case of self-seeding, when it might be feasible to mow it and handle it as we handle alfalfa in hay making. If, however, the plants are single it would seem necessary to adopt some other system of gathering it, probably the best method would be to turn up one side of the row and cut off the root with a chisel-like instrument. It would have to be handled as green as possible as, when dry, the leaves drop off badly.

The statement is made that animals eat it readily. To again quote the California Bulletin 125, p. 8: "At Tulare sub-station saltbush was fed to sheep, cattle, horses and hogs. With sheep the ration was increased until some received nearly their whole sustenance for months at a time from this plant, keeping in excellent condition, and being turned off to the butcher as 'fat mutton' without any other food except a little straw."

Other testimony on this point given on the same page, but by correspondents, is by no means so favorable, for some say "stock won't eat it." All shades of opinion between these two extremes seem to have been expressed by the correspondents in regard to the readiness with which it is eaten. On page 26 of the same bulletin, Prof. Jaffa states: "It is not advisable to feed the saltbush alone, particularly in the air-dried state, owing to the high percentage of the saline ingredients, and the general uninviting appearance and condition of the saltbush hay. In cases of emergency, however, sheep and cattle have existed altogether on this material through an entire season." These quoted statements, at least some of them, are general statements which contemplate other saltbushes as well as the *A. semibaccata*, which is the one had in mind in this bulletin.

We have fed it both green and dried, but almost exclusively to sheep. In one experiment we fed it to a horse. When fed green we had no trouble in inducing a lot of three sheep to eat it. The horse had been pasturing on it to some extent before we began feeding it to him as his only fodder. The sheep were fully matured animals in good condition; the weather during the time of the experiment, as well as all other conditions under which it was made, were altogether favorable. The time of feeding between weighings was three weeks. The result was that the lot had neither gained nor lost. The horse was not weighed, but we assumed that he had not lost materially, if at all; he ate the green fodder readily. At first the sheep showed the laxative qualities of the saltbush to a slight etxent, but this was of short duration and was at no time serious; the horse also showed it at first, but in this case it was also of short duration. There is doubtlessly a difference in individual animals in regard to the effects of this as well as any other fodder and it may be of a little interest to some to know that of the three sheep fed in this experiment, one gained a pound, one lost a pound, and the third just maintained its weight.

The green fodder was not analyzed, nor was there any account taken of the amount of the green fodder eaten; the only care taken was that they should have as much of the fresh fodder as they would eat. Samples of hay, however, were prepared from plants taken from different portions of the plot, as it varied considerably in the character of its soil. This feature of the experiment will not be mentioned further, but it is probably the cause of the very considerable variations shown in the analyses of these samples.

The plot of ground on which the saltbush grew was in parts as strongly alkalized as any of which I had knowledge and was poorly drained, still we had previously grown sugar beets on the plot and obtained a yield of 19 tons to the acre and the beets were of excellent quality. Some portions of the plot, too, had been manured, so that it is quite right that the samples of saltbush hay should vary somewhat in their composition if these things have any influence on the composition of growing plants.

As to the amount of hay we would be justified in expecting to obtain from an acre, I can give no opinion, as no data on this point was obtained.

I have grown some of this plant for the past eight seasons, but at no time since the first season have I had it on a measured plot, and the first season I obtained nothing like a good stand. On this point I will again quote Bulletin 125 of the California Station: "In February, 1896, saltbush seed was drilled here on the surface, in rows eight feet apart, and by September, when visited, the surface

was nearly covered. A part of the crop was cut twice, yielding at the rate of four tons of hay per acre." This is a very modest yield compared with those indicated by some of the correspondents, which would figure out at least one-half more. This may all be interpreted when applied to our conditions that the saltbush may be expected to yield a large crop of hay per acre provided the stand is good.

The composition of the crop of 1900 is given in the following table:

COMPOSITION OF SALTBUSH (*A. semibaccata*) HAY.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Sample 1	6.16	17.90	1.18	13.21	23.79	37.76
Sample 2	7.94	19.48	1.09	13.70	24.34	33.45
Sample 3	8.34	17.02	1.17	9.41	28.31	35.75
Sample 4	8.45	15.07	1.12	8.70	28.00	38.66

For the leaves and stems we obtained the following:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Leaves	6.42	24.29	1.66	15.92	8.99	42.72
Stems	5.25	8.75	0.72	6.46	44.67	34.15

The ratio of leaves to stems in a sample grown in 1906, which we may assume to be representative, was 8.6 to 6.5, or in round numbers, 60 per cent. leaves and 40 per cent. stems, according to which an average hay should contain about 12.2 per cent. proteids based on the analyses of leaves and stems given above, but the average percentage of protein indicated by the analyses of the four samples of hay is 11.26 per cent. This average is probably too low, owing to the low percentage of this constituent in samples three and four, both of which contain about or even less than one-half the amount of proteids found in later samples.

The four analyses, as previously indicated, serve to show how this hay may vary in quality even from the same field when no other condition than the variation in soil conditions can be appealed to as suggesting a plausible explanation; this is apparently a sufficient cause for the lack of uniformity in the published analyses of this hay, which is evident from the following, which are all of such analyses that I have been able to find:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Arizona Rep. 1903	6.30	17.90	2.11	14.13	20.75	38.81
California Bulletin 125	7.05	19.37	2.01	11.64	15.88	44.05
California Bulletin 125	10.00	17.74	1.47	14.14	20.18	36.54
South Dakota Bul. 69	7.40	13.09	2.05	18.87	25.97	32.62

In our analyses of the samples grown in 1900, we notice a variation of five per cent. in the protein content, but an extreme of

seven per cent. in the four analyses above quoted. In other samples which will be described later we will find that this hay may contain even a higher percentage of protein than is shown by the South Dakota sample.

A little over two years ago I thought the time opportune to publish these observations on the probable value of this saltbush, especially to those sections of the State where the rainfall is usually too scant to grow good crops of other forage, but on looking up the literature there seemed to be so little positively established, particularly concerning its digestibility and feeding value, that it seemed wise to defer publishing them until additional data relative to these points had become available. We, therefore, began anew and grew another crop of the saltbush and determined its coefficients of digestion, using three sheep, wethers going on two years old, for this purpose.

This crop was started by raising the seedlings in boxes and transplanting them, but owing to a number of things, over which I had no control, it was very late in June before the seedlings were transplanted to the plot set aside for this experiment. The soil was of good quality and in good condition and free from alkali, and the water used for irrigation was likewise free from these salts. The plants grew very well and seeded abundantly, though set out so late in the season. We had no intention of trying to establish the minimum length of the season sufficient to grow a fair crop of this hay, but the accidents happening to this experiment show that if the plants get a good start by July 1st they will do well in this portion of the State. This crop was gathered and cured on sheets under the direction of Mr. F. Knorr, assistant in Agronomy, so that we had the whole plant, leaves and stems, to feed.

The sheep were taken from fattening pens, where they had been receiving a full feed of alfalfa hay and some grain. They at first received alfalfa hay alone, then alfalfa and saltbush hay, the latter being gradually increased till they received saltbush alone, when the preliminary period of the feeding began. The sheep had in the meantime become somewhat accustomed to being handled and also to their harness. The sheep did not seem to really like this hay, one in particular, sheep No. 1, continued to protest against it, but in the end the experiment proceeded quite satisfactorily. In the preceding experiment it will be recalled that we had sheep at last three years old. They were accustomed to the person feeding them, to the pens in which they were fed, and wore no harness to annoy them and were not handled. The result of feeding them green saltbush, a period of three weeks elapsing between weighings, was that the lot just maintained its weight with a variation of only one pound in any sheep. The fodder was green and more inviting

than the hay, and all of the conditions under which the experiment was conducted were favorable. In this second experiment we also used three sheep, young ones, and made them just as comfortable as possible, and again the results indicate that this hay fed alone will simply maintain the weight of the lot. In this case sheep No. 1 gained ¼ of a pound; sheep No. 2 gained ¾ of a pound, and sheep No. 3 lost ¼ of a pound. The total weight at the beginning of the feeding period was 243.25 pounds, at the end of the period 244.0 pounds, a gain of three-quarters of a pound. It was rather surprising that sheep No. 1 should show any gain, for the animal evidently did not like the hay and ate much less of it than the others, about two-fifths only of the average of the other two sheep. I will not go into the details of this case, but do not think that it should be included in averaging the results. The only good purpose that it serves is to show how very different the results with some individual animals may be from the average, and further to emphasize the fact that some individual animals do not take kindly to this fodder. Though the general tenor of the statements regarding this point would lead me to infer that sheep take to it better than other animals. The composition of this hay, made from quickly grown plants, the feeding data, composition of the feces and the coefficients of digestion are given below:

COMPOSITION OF THE SALTBUSH HAY, ORTS, AND FECES.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	3.645	18.635	1.370	20.600	16.382	39.368
Orts—						
Sheep No. 1	3.610	21.668	1.460	20.820	15.233	37.209
Sheep No. 2	3.595	24.251	1.400	20.310	13.287	37.157
Sheep No. 3	3.485	22.156	1.400	20.500	14.502	37.957
Feces—						
Sheep No. 1	4.560	14.974	2.350	7.940	35.417	34.759
Sheep No. 2	4.525	15.894	2.240	8.090	32.142	37.109
Sheep No. 3	4.820	17.848	2.880	7.750	31.205	35.497

Experimental Data—Sheep No. 1 received 6,577 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	6337.27	1225.62	90.11	1354.86	1077.44	2589.24
Orts	4192.00	942.34	63.50	905.46	662.48	1618.22
Consumed	2145.27	283.28	26.61	449.40	414.96	871.02
Voided	1089.93	171.03	26.83	90.67	404.46	396.94
Digested	1055.34	112.25	-0.22	358.73	10.50	574.08
Coefficients of Digestion	**49.19**	**39.57**	.....	**79.74**	**2.53**	**58.85**

This animal weighed at the beginning of the experiment 78¼

pounds, and at the end 78½ pounds.

Sheep No. 2 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2056.32	517.28	29.86	433.21	283.41	792.56
Consumed	5592.34	962.02	78.90	1201.99	1016.99	2332.44
Voided	2195.93	365.57	51.52	186.07	739.26	853.51
Digested	3396.41	596.45	27.38	1015.92	277.73	1478.93
Coefficients of Digestion	**60.87**	**62.00**	**34.70**	**84.52**	**27.31**	**63.41**

This sheep weighed at the beginning of the experiment 79¼ pounds, and at the end 80 pounds.

Sheep No. 3 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2565.37	588.91	37.21	544.89	385.45	1008.89
Consumed	5083.29	890.39	71.55	1090.31	914.95	2116.11
Voided	2028.29	380.34	61.37	165.94	664.98	755.66
Digested	3055.00	501.05	10.18	924.37	249.97	1360.45
Coefficients of Digestion	**60.10**	**57.28**	**14.23**	**84.78**	**27.29**	**64.29**

This animal weighed at the beginning of the experiment 85.75, at the end 85.5 pounds.

The average coefficients of digestion for sheep Nos. 2 and 3 are, for the dry matter, 60.48; ash, 59.64; fat, 24.46; protein, 84.65; crude fibre, 27.30, and for the nitrogen free extract, 63.83.

The deportment of sheep No. 1 and the data showing the results obtained with this animal do not justify the inclusion of these results in stating the average coefficients found. We notice that the animal consumed only 2,145.27 grams of dry matter and digested 1,055.34 grams in five days and still maintained its weight or a little better, as it gained one-quarter of a pound. This animal was a light eater, even of alfalfa. In addition to these facts the coefficients of digestion are altogether too low in comparison with those found for the other sheep and can simply serve to show that the protein and nitrogen free extract have high coefficients of digestion, while the crude fibre is very difficultly digestible.

A comparison of these coefficients with some of our well known fodders may be of some service. The coefficients for alfalfa, timothy and native hay have been taken from Bulletin 93 of this Station. Those given for the oat hay are averages taken from Bulletin 77, p. 20, U. S. Department of Agriculture.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Alfalfa	62.05	57.67	29.86	72.54	49.93	72.89
Timothy hay	51.03	65.63	69.32	43.35	36.08	54.99
Native hay	50.53	42.52	20.55	62.33	55.56	51.30
Oat hay, average	49.30	34.60	54.20	43.50	52.00	61.90
Saltbush hay (A. semibaccata)	60.48	59.64	24.46	84.65	27.30	63.83

It will be observed that the composition of the saltbush compares very favorably with that of our best fodders. The proteids are high, especially in the South Dakota sample and the one used in our digestion experiments, 18.87 per cent. in the former and 20.60 per cent. in the latter. While the nitrogen free extract is lower than in the hay made from grasses it is quite as high as in the leguminous hays, alfalfa, or pea-vine hay. The crude fibre is low and the ash exceptionally high. The proteids present are not only high in percentage, but they also have a very high coefficient of digestion—84.65—which is, I believe, a higher coefficient than has been found for the proteids in any other hay and which has been approached in the case of but few hays. The ash is present in large quantities and is highly digestible, as one would expect, because it consists very largely of alkali salts. No apparent inconvenience was caused the sheep by the ingestion of these large amounts of ash constituents, except in the early part of our first feeding experiment, when the saltbush was fed green, but in this case the trouble was of short duration and did not recur. The crude fibre is not very abundant and has a low coefficient of digestion.

In spite of all of these good points the results of our two experiments with sheep indicate that the saltbush, when fed alone, will just maintain the animal. The results were the same whether it was fed green or in the form of hay. The leaves are not greedily eaten by the sheep; perhaps the very large amount of ash constituents present in them has something to do with this. There would seem to be no question but that in order to get the best effects out of a fodder containing 20 per cent. of protein it should be mixed with another poorer in nitrogenous substances.

This plant is supposed to grow particularly well on alkali soils. I found that it does well on soils which are considered as free from alkali, but remarkable differences seem to exist in the composition of the plant and also in that of the ash. The samples 1 to 4 inclusive were gathered from the same plot of ground; the soil varied, and we find that the proteid content varies by five per cent. Again, one of the California samples contained 11:64 per cent., while the South Dakota sample carried 18.87 per cent., and our last sample used in the digestion experiment contained 20.60 per cent., an extreme difference of 11.90 per cent., which, I believe, to indicate

the ability of this plant, to vary in composition according to the soil conditions under which it may be grown. Climate has nothing or very little to do with this case, as two of the samples referred to were grown at this Station.

The high content of mineral matter—ash—leads directly to the inference that the plant makes a heavy draft on the soil, especially as the plant is not only rich in ash but also yields a heavy crop. The California Experiment Station cut at the rate of 5½ tons of hay per acre, (Cali. Ex. Sta. Bul. 125, p. 6.); others give a much larger crop (ibib. p. 7), where a green crop is given as approximately 30 tons, which would not be less than 6.5 to 7 tons of hay. The hay made from this saltbush carries about 17 per cent. of ash, the sand and dust deducted. This would mean the removal of from 900 to 1,200 pounds of lime, magnesia, potash and soda from each acre of land, of which, according to my analyses, from 288 to 384 pounds would be potash and from 252 to 336 pounds would be soda. There would further be removed from 64 to 83 pounds of phosphoric acid.

These facts are of interest principally to show that the plant is a very heavy feeder, more so indeed than most useful plants. While alfalfa is a heavy feeder, removing from 180 to 200 pounds of mineral matter with each ton of hay, it is far behind the saltbush in this respect, which will remove not far from 340 pounds with each ton of hay. This matter is of little interest so far as this bulletin is concerned, still it may be worth while to consider the composition of the ash of this saltbush.

ANALYSES OF THE ASH OF THE AUSTRALIAN SALTBUSH, *Atriplex semibaccata.*

	Alkali Soil.	Alkali Free Soil.	Alkali Soil.*
Carbon	Trace	Trace	
Sand	3.82	10.93	16.24
Silicic acid	1.24	4.60	
Sulfuric acid	3.46	2.14	2.64
Carbonic acid	16.88	21.51	....
Phosphoric acid	3.54	3.43	2.80
Chlorin	20.80	5.82	24.33
Potassic oxid	14.37	16.02	11.42
Sodic oxid	23.79	14.85	35.39
Calcic oxid (lime)	8.54	13.27	5.79
Magnesic oxid	6.94	6.20	3.23
Ferric oxid	1.23	0.90	1.38
Aluminic oxid	Trace	1.21	1.95
Aluminic oxid	Trace	1.21	1.95
	104.75	100.99	105.39
Oxygen equivalent to chlorin	4.69	1.31	5.35
	100.06	99.68	100.04

*California Bulletin 105, p. 13.

The most striking differences are shown in the chlorin content. The California sample shows that almost one-fourth of the ash is represented by chlorin, while our sample, grown upon good, upland soil, considered free from alkali, shows that this element—chlorin—makes up only one-sixteenth of the ash. Again, the California sample shows three times as much soda as potash, while our upland sample shows more potash than soda. It is further clear at a glance that our sample grown on alkali soil approaches much more nearly to the composition of the California sample.

The plant takes up under the conditions of alkali soils a large amount of salt. The data given in the California bulletin show that it takes up, in round numbers, 800 pounds of salt, sodic chlorid, in producing five tons of hay. Our data show that it used about 600 when grown on alkali soil and only 163 pounds when grown on good, non-alkali soil. This hay, with its large percentage of ash, does not seem to be detrimental to animals, but it is an entirely open question whether the large amount of salt may not be a necessary condition for the perfect development of the plant.

The object of this bulletin is to present the facts concerning this plant so far as they are known for the consideration of our ranchmen, who need a forage plant which will produce from a fair to a good yield of reasonably good hay with but little rainfall. This plant seems to promise to fulfill all of these requirements. Though the California Station experimented with saltbushes for eighteen years and unreservedly recommended this one, the *A. semibaccata,* as the most promising one, and the Department of Agriculture at Washington distributed, if I am no mistaken, seeds of this plant, Director Wickson writes me that "the acreage in California is exceedingly small, probably not more than a small fraction of one per cent. of the amount which was contemplated." There may possibly be found an explanation for this failure of the plant to come into the popularity that its free growth and good composition seems to entitle it. They may have some other fodder which supplies their needs and is of easier culture, or easier to handle, but in those sections of our State which are of late years filling up with settlers and where the older inhabitants have had to have recourse to the Russian thistle, the coarse sand grass of the plains, or to the native saltbushes, this plant is worthy of a trial. It will not grow without any care. Even the native saltbushes are not always abundant, and this one will probably be no different except it receives intelligent planting and some nursing.

The following facts seem to have been established concerning this plant: First, when once established it will endure drought and

even make a good crop with less than five inches of rainfall.* Second, that stock will eat it or readily learn to eat it either green or as hay. Third, that it will produce very heavily under favorable conditions. Fourth, that it will, when fed alone, maintain the animals, and even better results are claimed for it. Fifth, that the hay is rich in protein, as rich or even richer than alfalfa. Sixth, that its coefficients of digestion are excellent, except for the fat or ether extract and crude fibre. Seventh, that it has no injurious effects on the animals even when they have no other fodder with it.

The following facts, however, remain, that it has not become popular, and that when fed alone it does not produce the results that its composition and coefficients of digestion would seem to warrant us in expecting. There is no reason for questioning the advisability of feeding something relatively richer in carbohydrates along with it, if they are at hand, but if they are not stock will live on this fodder alone.

RUSSIAN THISTLE.

On a preceding page reference was made to the use of this plant as a fodder. No one in any irrigated section would think of growing either the saltbush or thistle for forage. Press Bulletin 5 of this Station, by J. E. Payne, reprinted as part of Bulletin 64, reports the use of the Russian thistle in sections where other fodder cannot be raised readily. Some men report that it makes a good fodder, but other men of good judgment who have had experience in feeding this hay do not confirm the claim. Payne views it as an emergency forage. One man told me that he had tried it, feeding forty head of cattle, with very unsatisfactory results, and that many of his cattle died. As it is used to some extent in sections where there is no other available forage plant, or better where the supply of other and better plants is insufficient, I have studied the plant to a limited extent. There are only a few analyses of this fodder available. The following will serve to show the composition of the plant at various stages in its development:

ANALYSES OF THE RUSSIAN THISTLE.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Cut June 12*........	....	22.01	2.20	18.46	17.94	39.39
Cut June 26.........	....	18.79	1.84	17.72	23.19	38.46
Cut July 12.........	....	14.30	1.14	9.11	30.82	44.63
Small and tender†....	....	20.32	3.91	17.78	16.27	41.72
No thorns	....	21.21	3.18	14.71	22.45	38.45
Thorns out	....	18.25	2.97	13.45	21.62	43.71
Ripe	....	13.75	3.77	12.34	37.70	32.44

*California Bulletin 105.

*Iowa Bul. 26, p. 28, three samples cut June 12, 26, and July 12.

†Report Minnesota Exp. Sta. 1894, p. 35, four samples also Bul. 30.

Green thistle ‡.......	....	30.10	1.59	20.62	12.92	34.77
Hay	....	22.98	1.36	12.37	18.98	44.31
Hay	....	20.19	1.79	11.88	18.11	48.03
Green	....	29.29	1.79	19.16	12.21	37.55
Hay discolored	....	15.54	1.59	9.42	23.58	49.87
Hay, Fort Collins....	5.29	13.77	2.24	10.89	29.66	38.15

The last sample was gathered when the plants had thorns on, but were still green and succulent.

The ash constituents in this plant are high and indicate that it is a heavy feeder, especially on potash, as the analyses show. The composition of this ash seems to vary considerably.

ANALYSES OF THE ASH OF THE RUSSIAN THISTLE.

	Akron, Colorado.	Fort Collins, Colorado.	Minn.* Sample Plants Small.	Minn. Sample Thornes Well Out.	Minn. Sample Ripe.
Carbon	3.95	none			
Sand	11.25	0.90	1.93	2.43	3.95
Silicic acid	0.73	0.49			
Sulfuric acid	2.73	2.64	1.52	1.62	4.39
Carbonic acid	21.56	22.38	19.28	20.25	17.34
Phosphoric acid....	3.70	3.19	3.49	4.00	3.11
Chlorin	4.29	13.51	....	....	1.56
Potassic oxid	28.68	44.10	26.82	31.21	27.37
Sodic oxid	0.85	0.82	9.16	4.25	12.46
Calcic oxid	16.44	9.42	26.37	24.55	22.39
Magnesic oxid	5.52	5.17	9.66	7.66	5.56
Ferric oxid	0.89	0.27	0.86	1.01	0.85
Alumnic oxid......	0.52	Trace	....	....	....
Manganic oxid (br)	0.07	0.04	....	....	....
	101.16	102.93			
Oxygen equivalent to chlorin	0.98	3.04			
	100.18	99.89	99.09	96.63	98.97

We find the phosphoric, sulfuric and carbonic acids given in the Minnesota analyses as phosphates, etc. I take it that this is a misprint and that the corresponding acid is intended.

These analyses do not agree at all. The chlorin, for instance, varies from 1.56 to 13.51, and my own samples differ by more than nine per cent. The only thing clearly evident is that this plant is a heavy potash feeder.

*Report Minnesota Experiment Station, 1894, p. 36.

‡Report Kansas State Board of Agriculture, 1902, p. 25, five samples.

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The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Dewberry Growing

BY

O. B. WHIPPLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
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The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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Dewberry Growing.

By O. B. Whipple, B. S.

As Colorado is noted for its variety of climates so is it remarkable for its diversity of products. We are fast learning that certain localities are best adapted to growing particular kinds and even varieties of fruit and the grower is to be commended who adapts himself to his environment and becomes a specialist. We have our recognized peach sections and we might, if we do not already, have our recognized dewberry sections. Probably the dewberry growers of the Plateau valley, a valley tributary to De Beque, Colorado, and the Grand Valley proper, have gained a greater name for their dewberries than have those of any other part of the state and it is the purpose of this bulletin to outline their method of culture for the benefit of those similarly situated. Here, dewberries are grown at an elevation varying from 5500 to 6500 feet and surely finer berries cannot be grown anywhere. Lower elevations, at least in the western part of the state, are not well adapted to the culture of this fruit on account of the extreme heat of summer, the berries are short and seedy as compared with the long luscious berries grown at higher altitudes. The fruit seems to develop best where the maximum temperature is not above 90°, and probably maximum temperature is a better guide than elevation. It must not be inferred, however, that dewberries may be grown in all localities favored with such summer temperatures; severe, drying winters may prove too trying for dewberries in localities otherwise well adapted to their culture.

That dewberries may be grown profitably in localities where the maximum temperature often runs above 95° in the shade, during the picking season, is proven by the returns from a plantation near Fruita, Colorado, in the season of 1908. Here three-quarters of an acre produced 345 crates of berries and brought a gross return of over $650. The berries were not as large as those grown at higher elevations. The variation in season in different localities is better understood when we say the picking season at Fruita extended from July 7 to August 1, while at Plateau City, Colorado, Mr. Baldridge's patch was at the height of its season on August 1.

Although Card in his "Bush Fruits" seems to doubt the value of the dewberry and suggests that its place may yet be taken by some early ripening blackberry, there is no danger of such a change of favor in Colorado. It ripens earlier than most blackberries and the plantation is much more easily handled. It is in a class by itself and unfruitfulness due to lack of proper fertilization or other causes is a misdemeanor of which the Colorado dewberry, in suitable locations, is not guilty. At present, however, the acreage of dewberries that can be profitably grown will no doubt be limited by the short life of the berry in transit and hence the accessible markets. As yet we have not learned to ship the fruit any great distance—it may almost be said that they must be on the market within thirty-six hours after picking. Unless by

some means we can lengthen the life of the fruit in transit, over-production may easily take place. For this reason it is encouraging to think that the industry is new and that probably much is to be learned about the proper handling of the fruit for shipment.

Quite a variation in season may be found in different sections and altitudes, and all dewberries do not necessarily come into competition.

Soils and Locations. In its wild state the dewberry is found growing on comparatively light sandy soil and if this is significant it would suggest that our sandy mesa soils are the best adapted to its culture. Yet in Colorado, the dewberry, like our tree-fruits is grown on almost any kind of soil. Considered from the standpoint of both ease of culture and adaptability, however, sandy soils free from rock or gravel are best adapted to dewberry growing. Since the plants must be covered for the winter, and as they are generally covered with the soil about them, any considerable amount of gravel or rock is undesirable. In the introductory remarks it has been suggested that the dewberry does not develop well in a hot climate and here it may be said that much may be gained by choosing a northern exposure upon which to set the dewberry patch. The best growers recognize this as an important point, the fruit not only develops better but the vines get through the trying days of winter and spring with less injury.

Propagation. The dewberry may be propagated by layering the tips or from root cuttings. In fact the plants are so easily secured that one may generally get them from his neighbors plantation more easily than from a nurseryman. If plants are required by the wholesale a good plan is to plow a furrow along the row, place the tips of the runners in this and turn a light furrow back upon them; the tips must be actually covered. This work should be done before the opening of the picking season in most altitudes, and the plants will be ready for next spring's setting. Deep cultivation that will disturb or break large roots will cause many new plants to start. If an old bed is to b. discarded, a good crop of plants may be secured by thoroughly plowing and working down the bed in the spring allowing the young plants to spring up from the broken roots the following summer. Root-cuttings, from roots the size of a lead pencil, may be taken in the fall, stored in moist sand over winter and planted out in nursery rows the following spring. If these root-cuttings are well cared for during the winter and planted three inches deep in a good soil, kept well moistened, a fair percent will produce plants. Root-cuttings taken in the spring and planted in the same way will also give fair results. The dewberry does not sucker as freely as the blackberry, neither does it root as readily from root-cuttings.

Preparation of Land for Planting. In an irrigated section the first step in the preparation of land for any crop is proper leveling, low spots where water settles or high spots difficult to irrigate materially cut down the dewberry yield. Best stands are secured when the ground has been deeply plowed, well worked down and pulverized; no doubt fall preparation is advisable for spring setting.

Planting. The majority of our dewberry beds are from spring settings but many of our experienced growers seem to be of the opinion that fall setting would prove as satisfactory and would bring quicker returns. I see no reason for not setting in the fall, the plants would necessarily be quite tender the first winter but could be well protected and should suffer no injury. Planting in the fall should be done in early September and spring planting as soon as the ground can be worked. As to distances for planting there is still some dispute, but, if the plants are to be allowed to grow prostrate, setting 5' x 5' seems to be the most satisfactory system. They can be pruned accordingly and cultivated either way. If grown on a wire trellis, rows six feet apart with plants three feet in the row would no doubt be a better system. When planted in the young orchard, the distance can be made such as to best utilize the space. There is no particular objections to planting dewberries in the young orchard but the grower is to be cautioned about crowding the trees and advised that in most cases it is not a crop for the old orchard.

For planting, the ground is furrowed out one way and cross marked. The plants are dropped in the furrow at its intersection with the cross-mark, and partially covered with the foot. The furrow is turned back, the plants straightened up, the soil firmed about them, and the job of setting is completed by running water down the row. As with any other plant, the top should be cut back at setting time to offset the loss of roots in digging.

Cultivation. The cultivation of the dewberry patch should not be unlike that for any other bush-fruit. It should be well-cultivated in the early part of the season to keep down the weeds and conserve the moisture. Cultivation stops at the opening of the picking season and is resumed again at its close, continuing until the end of the growing season. Since deep cultivation which disturbs or breaks the roots tends to start objectional plants in the middles, the early cultivations and possibly the later ones should be rather shallow. If the plants are allowed to run for the purpose of being trained on a trellis, cultivation must be in one direction; when checked equal distance each way the general plan is to keep the middles open only one way. While it may be possible to overgrow the plants by continual cultivation, it is better to counteract this by withholding water rather than by discontinuing cultivation. Good cultivation is no doubt conducive to vigorus, but not necessarily to rampant growth.

Irrigation. There are really no tricks in irrigating dewberries. The ground should be kept moist and in good condition during the early part of the growing season. The young plants will stand a good deal of water the first season. During the picking season it is the common practice to water after each picking, just a light surface watering. This supplies the roots with the needed moisture to swell the berries to good size and by keeping the surface of the ground moist the berries ripen better, there is less loss from the drying of the fruit. It would be a good plan, no doubt, to try to induce early maturity of the canes by withholding water after the close of the picking season. In localities where the winter snowfall is not great the dewberry patch should be given a late fall irrigation.

Fertilizing. The grower of dewberries cannot expect that the plants will continue bearing good annual crops without fertilization. If properly cared for, there seems to be almost no limit to the duration of the plantation. Good stable manure is one of the best fertilizers for our Colorado soils. It may be applied in early spring before uncovering the plants and the uncovering process as well as early cultivations will help incorporate it

with the soil. Frequent light applications are preferable to heavy and irregular ones, as they tend to promote more uniform growth and yields.

Pruning. In western Colorado at least, dewberries are allowed to grow prostrate, growers say it is too expensive to trellis them and it might be added that the present system seems highly satisfactory. No doubt, under certain conditions, trellising would be advisable but surely could not increase the yield any considerable amount. Where the plants are grown on a trellis, they receive no summer pruning as a rule; the new canes are allowed to trail on the ground under the trellis while the fruiting canes are tied to the wires. The only pruning the plant requires—unless it be a clipping back in August to induce early maturity—is cutting out the old canes in the fall or spring and shortening the new ones to three or three and one-half feet. A two-wire trellis is generally used, the top wire being about three feet from the ground. The training of the dewberry without the trellis requires a little more care in pruning but saves the labor of tying up and allows of early cultivation either way. The first pruning consists in tipping the new growths when they have attained a length of twelve or eighteen inches, the canes then stand upright above the old wood and the tips may be mowed off with a sickle or large knife. It is important that this pruning be done at the right time, do not wait until the canes are longer and then cut back to eighteen inches or weak lateral canes will be the result. This early pruning forces out lateral canes and thus increases the bearing surface as well as stiffen the lower part of the cane, making it support itself better. The general practice is to prune the second time just before picking begins. The main object of the pruning seems to be to get the new wood out of the way of the pickers. At this time the lateral canes forced by the first pruning are cut back to two or two and one-half feet, they should be left long enough to shade the old wood and the fruit, yet short enough to be easily lifted by the pickers. This pruning must not be delayed too long as it starts new growth which should have time to mature, at its best it is not satisfactory and it is probable that the growers will yet learn to avoid this pruning. The third pruning is administered the following spring, and consists in removing all old canes and shortening-in the new canes that may have grown too long. There seems to be no reason why this pruning may not be done before covering in the fall other than that the foliage makes the pruning more difficult.

Winter Protection. The dewberry is not hardy in most parts of Colorado, consequently the canes must be covered during the winter. The difficulty seems to be that the canes do not mature well before frost and they tend to dry out during the dry winter weather. Just before the ground freezes it is the common practice to bunch together the canes from each plant and cover them with a light covering of soil. Where the vines are allowed to grow together in the rows, they are kicked apart, strung out, and covered in the open middle. The covering of dirt need not be heavy, just enough to hold the plants down throughout the winter. There is danger in covering the plants too deep, especially if they carry heavy foliage, as the canes are liable to become heated. The bare bases of the canes should be well covered. Most growers cover with a shovel, one man covering about 1500 plants in a day. The vines must be uncovered in the spring before growth starts. The canes are not injured by light spring freezes, and the new growth that starts while the vines are still covered is either knocked off in the process of uncovering or is killed by the hot sun afterward.

The canes may be lifted with a fork and the dirt scraped away from about the crown, leaving the rest of the leveling to the cultivator.

Picking. In growing dewberries on a large scale one of the serious problems is that of securing pickers. The average picker will pick from five to seven crates a day, and this means that it will take from eight to ten average pickers to pick an acre per day. The general practice is to pick every third day, and the large patch may be divided so as to furnish the pickers employment every day.

The pickers must at least wear a glove on the hand used to lift the vines and most of them wear a glove with the tips of the fingers removed on the picking hand. Some growers supply the pickers with a twelve-basket carrier, or two if the pickers are fast and able to carry them. Others advocate the use of the regular shipping crate holding twenty-four baskets. A bale may be made of heavy wire bent in a way to clamp into the grooves that serve as handles in the end of the crate. Of course crates used to pick in cannot afterwards be used as shipping crates. The deck boards and baskets for the second tier are carried along and placed in position when the first tier is filled. In this way the picker carries a full crate in one hand and at the same time does not expose them to the sun for any length of time. A piece of heavy cloth large enough to cover half the crate may be tacked by two corners across the center of the crate and used to shade one end of the crate while the other is being filled. The pickers should be made to grade the fruit, and the best way is to have them put the culls in certain boxes and pay them for picking these the same as first-class fruit. This plan provides a place for fruit the picker gathers and hates to throw away because it fills up. Dewberries should be picked when a full glossy black. Berries which have gone beyond this stage and turned a dull or more ashy color are too ripe to ship. The cull box is the place for over-ripe, dry, and poorly colored berries. Ripe berries start mould if packed for shipment.

Dewberries should not be picked when moist, as after a heavy dew or rain. Pickers are paid by the crate, thirty cents, if they pick part of the season, and thirty-five cents if they finish the season. If the grower does not protect himself in this way, some of the pickers will leave him when picking gets poor.

Packing. Since dewberries were first grown in Colorado several styles of packages have been used, but the crate known as the Doube-deck Raspberry Crate and now commonly used comes as near perfection as any. This crate holds twenty-four pint veneer boxes, twelve in each deck. When the bottom tier of boxes is in place a second bottom similar to the first is dropped in—the ends of the crate being supplied with grooves to support it—and the second tier rests upon this. The crate is arranged in a way to give perfect ventilation, and good ventilation is essential in shipping dewberries. The general practice is for the pickers to sort the berries and then all the packer has to do is to see that the boxes are full and not overfull, and possibly throw out a few defective berries overlooked by careless pickers. When packed and covered the crates should be ricked up end to end, preferably under an open shed, and allowed to thoroughly air out before shipping. If possible, it is a good plan to let them air over night and ship in the morning; unless well aired out the fruit molds in transit. Shippers should also insist on the car being well ventilated; icing only seems to aggravate molding.

As in the packing and grading of any fruit, the berry grower has an opportunity to establish a reputation for his product. So long as the number of dewberry growers is limited and the matter of grading and packing is not an association problem, the individual grower should put up a pack that he is not ashmed of and stamp his name and address upon the crate. Mr. Jas. P Baldridge, the veteran dewberry grower of the Plateau Valley, and to whom I am indebted for much valued information and help in the preparation of this bulletin, has adopted this plan and is known the state over for his dewberries. He could dispose of the entire output of his five-acre patch through mail and telephone orders but prefers to let a Producers' Association handle the bulk of the crop. Such a plan relieves the grower of much responsibility and associations are better collectors than individuals. The man who receives the fruit from the pickers and crates it for shipment should always be on the lookout for poorly colored, defective, or over-ripe berries. Pickers often pick small, dry berries and these should not be allowed to go in a first-class pack. The packer also sees that the boxes are well filled but not overfull.

Varieties. In spite of the fact that most eastern growers advise interplanting of different varieties to insure perfect fertilization we see no need of taking such precautions in Colorado. The Lucretia is practically the only variety grown in our best dewberry sections, yet we see no tendency toward imperfect fertilization. The variety seems perfectly satisfactiry and there seems to be little occasion for testing new ones. The Lucretia stock varies considerably and could no doubt be improved by proper selection. From the literature on the subject it would seem that only one other variety, the Mayes, gives promise of equaling the Lucretia.

Insects and Diseases. So far the dewberry in Colorado is exceptionally free from the attacks of insects or plant diseases. No insects have been reported as doing serious damage. The common leaf spot of the ramblers has been observed in only a few plantations, and here it seemed to be doing no serious damage. The work of this parastic fungus is first indicated by purplish spots which appear on the leaves. These spots later dry out and turn a lighter color and show a few dark pustules in the center. Still later the diseased tissue may drop out entirely giving the leaf the appearance of having been riddled with shot. Should it become necessary to spray for this it could no doubt be controlled with one of the standard fungicides.

Yields and Returns. A dewberry plantation in good bearing will yield from three hundred to four hundred crates of berries per acre. Mr. Baldridge's patch, set on four and one-half acres of ground but with enough plants for five acres, was set in 1903. In 1904 it yielded 125 crates of berries, in 1905, 1800 crates; in 1906, 1800 crates and in 1907, 2000 crates. It would probably be hard to give a satisfactory estimate of the cost of production of dewberries. The crate costs the grower 27 cents and picking 35 cents per crate, plus probably 5 cents for overseeing and crating the fruit. Estimating the cost of production at $1.00 per crate this would leave 25 cents per crate for other work. With a yield of 350 crates per acre this would mean an allowance of $80.50 for other labor, irrigations, cultivating, pruning, covering etc. Possibly this is not high enough; but granting that the cost of production is $1.25 per crate, which is surely high enough, the grower still nets a return of $1.00 per crate. At present the average price paid for dewberries has been $2.25 per crate F. O. B. the nearest shipping point.

The Loganberry.

In some of our best berry sections, the Loganberry is sharing popular favor with the dewberry. This berry is supposed to be a hybrid of the red raspberry and the Western dewberry, and it resembles both. The fruit is almost identical in shape with the dewberry, possibly a little shorter, but has the color and flavor of the raspberry; in foliage it resembles the raspberry and in growth it has a trailing habit midway between the two. It has the advantage over the dewberry in that the canes stand up better, but it is not generally conceeded to be as good a producer. When fully ripe the berry is a little softer than the dewberry but apparently ships well, and so far it has sold for the same prices. Comparison of flavors is largely a matter of personal likes and dislikes, but in the raw state it is doubtful whether its flavor is as pleasing to most tastes as is that of the dewberry. Its flavor is improved by cooking and it makes a very fine sauce. As it is grown in a limited way, it is impossible to say whether it will prove as popular when grown more generally, or whether the demand is limited. It surely deserve a place in the home garden at least.

Its culture is practically identical with that of the dewberry. The plant is a little stronger grower and may profit with a little more room. It is possible that the first pruning may be omitted, but, on the other hand, this pruning may materially increase the yield by multiplying the number of fruiting canes. The fruit is a little harder to pick on account of a tendency for the calyces to cling to the fruit. It is picked, packed and handled for market as is the dewberry.

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Some Animal Diseases

[POPULAR]

BY

Drs. GLOVER, BARNES and KAUPP

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Some Animal Diseases.

BY

Drs. Glover, Barnes and Kaupp.

Introduction.

This publication is intended as a *bulletin of information* and in no sense a scientific treatise of subjects under consideration.

According to recent statistics there are something over $50,000,000 invested in livestock in the State of Colorado. There is probably no place where livestock of all kinds is generally more healthy. The loss we suffer is not so much from the ravages of any one or several contagious diseases, as it is from the aggregate loss from innumerable things, such as accidents, colics, pneumonia, poisonous plants, etc. Most of this loss is attributed to either ignorance, or carlessness and is preventable.

This constant loss of valuable animals, to the farmer and stockman must be figured as just so much taken from the profits, and in the end means success or failure of the enterprise. The most casual observation at once suggests the importance of education of the farmer and farmer boys, on the care and management of livestock, the recognition of the more common diseases, and vastly more important than all —how to prevent them.

This bulletin of information deals with a few conditions that seem to be of the most importance to stockmen of the state, just at this time. In it we hope to throw out a few hints that will be easily understood and of real practical value.

Sore Mouth Disease of Pigs and Calves.

(*Necrotic Stomatitis.*)

By Dr. Geo. H. Glover.

During the last fifteen months this disease has been a veritable scourge among hogs in Colorado. Calves and other species of animals have not been much affected. The name "sore mouth disease" is rather misleading because the disease is not always confined to the mouth.

Cause: The cause of this disease is a germ and nothing else can produce it, although improper food, dirty and unsanitary pens are in a way responsible (predisposing causes) for it. To grow a good crop of corn it is necessary to cultivate the crop and furnish other favorable conditions. In the same way, having the germs of disease planted, the disease is sure to develop if conditions (filth, exposure, lack of exercise, etc.) generally favorable, are existing. Experience has shown that the saying—"Anything is good enough for a hog," is a great mistake. Within the last year many examples have come under our observation where farmers taking exceptionally good care of their hogs have escaped and others in the same neighborhood have lost all the small pigs they had from this disease.

The germ of disease getting into a slight wound or sore anywhere on the body, or in the stomach, or bowels, will grow and destroy the

tissue until it has produced a deep cavity. It may be the jaw bone or end of the tongue, tips of the ears, or perhaps has involved a large area of the stomach. This is not the worst of it perhaps, for while the germs are growing, they secrete poisons (toxins) which are absorbed and poison the whole body.

Symptoms: When this disease gets among the herd the pigs from a few weeks up to a vear old are seen (first one or two) to be unthrifty; on examining the mouth, there is usually found a deep sore, (not always), the back is arched, there is a loss of appetite, and within a few days the pigs are dead. Examination of the carcass after death will always reveal the presence somewhere on the body (inside or out), of deep seated angry looking ulcers.

Prevention and Treatment: To allow this disease to spread among the herd is little short of criminal.

If your hogs are healthy and your neighbors hogs have this disease, see to it that you do not purchase any animals from him and thus infect your own herd. The farmer himself may carry the infection on his boots. Clean out the pens frequently, scrub out the feed troughs, and keep them well supplied with clean bedding.

If this is too much trouble, then be prepared to take the consequences. If the hogs have the disease it can be stopped with little expense of time and labor.

How to Proceed: First; isolate the healthy from the sick animals, dip all the healthy pigs in a barrel of the following solution: potassium permanganate 1-oz. to one gallon of water. Place all of these healthy pigs that have been dipped, by themselves in clean new quarters, and dip them once a week. Second; the sick pigs may be treated by burning out any sores with lunar caustic and dipping them like the others. Usually however, it will be better to destroy them and burn the carcasses. Third; *disinfect the premises.* Rake up all the litter and burn it. Whitewash the fence posts, plough the pasture, scrub the feed troughs in boiling water, burn sulphur in closed buildings. It may be necessary to follow this proceedure a second or even a third time. Success at the start is the reward of thoroughness with which every detail of the work of isolation and disinfection is carried out.

Lip and Leg Ulceration or Necrotic Dermatitis of Sheep.

BY DR. GEO. H. GLOVER.

This is an infectious disease of sheep which has recently appeared in the West. It is caused by the same organism as *sore mouth disease of pigs.* This germ (*bacillus necrophorous*) not only affects pigs, calves and sheep but may attack any warm blooded animal. People have been affected.

Before this germ can invade the body it is necessary for the skin or mucous membrane to be broken; the germ once having gained entrance into the tissue, begins its special business of tissue destruction, in whatever part of the body it has found lodgment. This organism is no doubt the cause of many of the persistent sores on the feet and legs of horses, sometimes on the neck and shoulders. In sheep the

legs and lips are more commonly affected. There is not much inflammation surrounding the diseased area, only deep, angry looking ulcers that will not heal and gradually grow larger. This condition of the lips of sheep is not to be confused with a sore mouth condition which often appears in sheep and lasts for a few days when they have first been put on heavy feed.

In case of infectious dermatitis the feet are especially liable to become sore, between the claws or just above the hoof; the mouth will become so sore that they can not eat and very seldom do they recover without treatment.

Treatment: If the sheep be watched carefully and upon the first appearance of the disease the ulcers are cauterized deep with a stick of lunar caustic, the disease may be checked. If the disease has progressed far, the ulcers penetrating deep into the flesh and the system poisoned by the toxins of the germ, it is better to destroy them and burn the carcasses.

If the disease has made its appearance in your flock proceed to clean it up in exactly the same way as is recommended in the preceeding article on sore mouth disease of pigs.

Poisonous Weeds.

By Dr. Geo. H. Glover.

The weed has been defined as a plant out of place. We have in the arid West probably a greater variety of plants, certainly a greater variety of poisonous weeds than can be found anywhere else in the United States. The different loco weeds easily take first place from the standpoint of the disaster wrought to the livestock interests of the State. The Experiment Station is doing everything possible with its limited means to investigate the different poisonous plants on the open range, and with the view especially of trying to determine some means of lessening the heavy mortality by prevention, antidotes, etc.

LOCO WEEDS.

About four years ago the Colorado Experiment Station undertook a co-operative investigation of the loco weeds in conjunction with the U. S. Department of Agriculture.

This much has been determined, as reported by the Bureau of Plant Industry, Bulletin No. 121, part 3.

Symptoms of Loco Poisoning: "The principal symptoms are the lowered head, rough coat, slow staggering gait, movements showing lack of muscular coordination, sometimes more or less paralytic symptoms, a general diseased nervous system, and in the later stages of the disease, extreme emaciation."

Pathological Changes: "The principal pathological changes are pronounced anemia of the whole system, diseased stomach walls, and in acute cases a congested condition of the walls of the stomach, while in chronic cases there are frequently ulcers. Generally speaking, locoed cattle have ulcers in the fourth stomach. There is an excess of fluids in the various cavities of the body. This is especially noticeable in the epidural space of the spinal canal. Here the effusion is more or less

organized, presenting the appearance of a gelatinous mass, which is especially abundant in the lumbar region and about the exits of the spinal nerves. In most locoed females the ovaries are found in a diseased condition.

Cause: According to the report of Albert C. Crawford, pharmacologist, poisonous plant investigation, "It is the inorganic constituents, especially barium, which are responsible for this poisonous action, at least in the plants collected at Hugo, Colo."

Ridding the Ranges of Loco Weeds: "In regard to the possibility of killing the weeds, it was found that this could readily be done in the case of fenced pastures. This is especially feasible with Astragalus mollissimus, because it occurs in comparatively small patches. Aragallus lamberti has a wider distribution, but it is not at all impossible to destroy this weed when in pastures. There seems to be no way of ridding the ranges of these weeds, however."

Treatment: "In regard to the second phase of remedial work, it was found that locoed cattle can in most cases be cured by a course of treatment with strychnine, while locoed horses can generally be cured by a course of treatment with Fowler's solution. The animals under treatment must not be allowed to eat the loco weed and should be given not only nutritious food, but, so far as possible, food with laxative properties. To this end magnesium sulphate was administered to correct the constipation which is almost universal among locoed animals. It should be noted, too, that magnesium sulphate may serve to some extent as an antidote to the poison.

It may be added, in regard to the question of immunity, that loco poisoning comes on in a slow and cumulative manner, so that there is no possibility of animals becoming immune."

LARKSPUR.

Barring the several species of loco weed, by far the most important poison weed in the State is three or four species of larkspur. The loss to the State from this source is something like $50,000 per annum.

In almost every instance where we have been called upon to investigate the poisoning of live stock in the mountainous sections of the State it has proved to be some species of this deadly family. The entire plant is poisonous up to the time that it flowers. It then not only becomes unpalatable to most animals, but loses a large part of its poison. When in flower it can easily be distinguished from all other plants by the color and shape of the flower, which has a projection on the back side, hence the name larkspur. All the different species have this characteristic shape, the blue or white flower, and so far as we know now all the different species are poisonous.

The poisoning occurs mostly in the spring when the plant is young, and during or immediately after a snow or rain storm. Cattle and sheep are much more frequently affected than horses. The animal usually starts for water, may fall down several times, stagger to its feet and try to keep going. Letters have been received frequently from different sections of the State describing a heavy loss through poisoning and accusing an unscrupulous neighbor of having willfully placed

poison in a spring or water hole. The reason why the spring is thought to be poisoned is because there is sometimes a little misunderstanding between the neighbors, and the fact that the cattle have been found dead near the spring has naturally lead to the supposition that the neighbor was wreaking vengeance by purposely poisoning his neighbor's stock. The real reason is, of course, that the animals as soon as they become distressed will start for the nearest water hole to drink and are often found adjacent to it.

The most active poison in the plant is called *Delphinine,* and in its action is very similar to aconite, depressing the heart's action and producing great weakness, and in many cases there is extreme bloating, the same as from alfalfa. Many antidotes have been tried, but only two appear to be of real benefit. The chemical antidote, potassium permanganate, has given results that are surprisingly satisfactory. The advantage in this drug is that it changes the poison and renders it harmless before it has been absorbed into the system. It is a most valuable antidote for poisoning by several of the alkaloids. With some little inconvenience it can be carried in the saddle bags by the cow boy and be the means of saving some valuable animals. If you wish to try this, go to your drug store and have put up a number of powders each composed of 30 grains of potassium permanganate and 30 grains of aluminum sulphate. When a poisoned animal is found it should be given one of these powders (regulate dose by the size of animal) in a quart bottle full of water. The other antidote is atropia sulfate, which is to be given with a hypodermic syringe which stockmen usually use for vaccinating their calves against blackleg. This antidote is used after the poison has been absorbed into the system. The tablets can be secured at any drug store, and carried along with the hypodermic syringe and a little bottle of water, and may be used by cow men while riding the range. If the animal is badly bloated it should be punctured high up on the left side with a knife, or better with a trocar and canula. This allows the gas to escape from the paunch, and is often sufficient treatment of itself. Bleeding seems to be the general practice and while this is not generally believed in now-a-days, either in the practice upon the human or the lower animals, yet in the case of larkspur poisoning it is claimed by stockmen to give beneficial results; if so, probably by relieving the passive congestion. Melted lard given at the very start would no doubt be of some benefit by mechanically preventing the rapid absorption of the poison. Never give tobacco, aconite, or anything that will tend to depress the animal. Stimulants are indicated, such as whiskey, ammonia, camphor, etc.

Next in importance to loco and larkspur is *wild parsnip* and *Death Cama.* Copies of Bulletin No. 113, "Larkspur and Other Poisonous Plants," may be obtained on application to the Experiment Station. The leaves of the wild cherry, monkshood, sage, skunk cabbage, ergot, sorghum, kaffir corn, and the rubber plant under certain conditions, mouldy hay, potatoes, carrots, etc., all come in for their share of the annual mortality in our domesticated animals.

A knowledge of the identity of poisonous plants, and conditions

under which they are most dangerous, would of itself be a great help to the stockman.

Blackleg.

By Dr. C. L. Barnes.

Blackleg (Symptomatic Anthrax) is a disease of young cattle and is caused by a germ. Most diseases of livestock are attributable either directly or indirectly to bad care and management, but this disease invariably strikes down the calves that have received the best care and are in the best condition.

Symptoms: One of the first symptoms noticed is the sick animal remaining away from the herd, usually lying down and not chewing its cud. If the animal is forced to move it appears stiff, usually in one fore leg. If this leg and shoulder be examined closely, it will be found that the muscles are swollen and tense. This swelling gradually increases as do all of the symptoms. The peculiar crackling sound, emitted when the hand is rubbed over the tumor is caused from gas which has accumulated under the skin.

If the swelling be lanced, a dark, frothy, bloody fluid runs out which swarms with blackleg germs. Death usually occurs in from six to forty-eight hours after the first symptoms are noticed.

The Season of Greatest Loss: Blackleg occurs in all seasons of the year. Reports from 1,656 stockmen show that May and June, and September and October are the months when the greatest losses occur. It would seem that it is greatest in wet seasons, for the sole reason no doubt, that feed is better in the wet season, and this is conducive to thrift and increases the susceptibility to the disease.

Treatment: As to treatment there is none. Practically all animals contracting the disease die. Our only hope is in the prevention.

Prevention: The fact that young cattle in a thriving condition are more susceptible, has led to the general belief that anything that will deplete the condition will act as a preventive, accordingly, various means of depletion have been tried such as chasing the animals, reducing the feed and water, bleeding, physic, seton through the dewlap, etc. This sort of thing however is very discouraging to the man who has been striving to keep his cattle growing, and besides when the disease has once appeared in the herd, such measures will not check it.

Vaccination: Vaccination will positively prevent blackleg; this is proven in laboratories where animals that have been vaccinated refuse to take the disease by inoculating them with the virus of diseased animals. The reason that some have not had satisfactory results from its use is that either the vaccine is not good or has not been properly given. Again occasionally a man will wait until his calves begin to die before vaccinating, and if they continue to die, he blames the vaccine. In such cases the calves were infected before vaccination and his efforts were and always will be in vain. Those who have made a regular practice of vaccinating every spring and fall and have exercised care in the work have generally reported excellent results.

Glanders.

By Dr. C. L. Barnes.

If your horse has glanders, or if any of your animals are sick or dying with what appears to be a contagious disease, it is your privilege and duty to notify the State Veterinarian at the Capitol Building, Denver, who will visit your place without expense to you.

Glanders is one of the oldest diseases known, its contagiousness being recognized as long ago as the seventeenth century. Glanders is caused by a specfic germ (Bacillus mallei) and affects horses, asses and mules. The goat, cat and dog sometimes contract the disease from living in stables with glandered horses. Pigs may contract the disease by inoculation. Cattle and chickens are immune. The disease attacks the mucous membrane of the nose, and may extend to the windpipe and lungs. When the lymphatic glands of the surface of the body are affected, the disease is known as farcy. The germs are found in the discharges from the nose and the farcy buds. The disease is transmitted to other animals, including man, by inoculation through wounds or mucous membranes. There are also many additional ways in which animals may be affected, such as common drinking troughs, feed boxes, mangers, hitch racks, harness, and any equipment used around an infected stable.

Symptoms: Glanders may occur in the acute or chronic form, or it may attack the surface of the body in the form of farcy. The acute form of glanders begins with a chill, high fever, the mucous membrane of the nose is at first hot and dry, and soon there is a watery discharge, which later becomes bloody. Nodules and ulcers form on the mucous membrane of the nose and discharge pus. These changes in the nose may take place in two or three days. There is also an abundant diarrhea, and the urine contains a large quantity of albumen. The patients become very weak and rapidly lose flesh.

The first symptoms of chronic glanders oftentimes are not easily recognized owing to the absence of distinct symptoms in the first stages of the disease. The first noticeable sign of the disease is a watery discharge from one or both nostrils, which later on become sticky and of a yellowish-gray or yellowish-green colored pus mixed with some blood coming from ulcers on the inside of the nose, and more particularly on the partition separating the nostrils. These ulcers are generally star shaped, and they may extend so deeply into the septum as to cause perforation.

When glanders affects the skin (farcy), one of the main symptoms may be the swelling of a joint with engorgement of the limb and nodules may form along the line of the lymphatics. These nodules vary in size from a pea to a hen's egg, and have a tendency to soften and discharge pus, after which they heal rapidly. New nodules may form, following the same course as the previous ones.

Manner in which Glanders may be distinguished from Distemper: In both these diseases there is a discharge from the nose. In distemper it is usually from both nostrils, while in glanders, as a rule, it is

from one side only. In glanders there are the characteristic ulcers formed in the nose, which, after healing, leave a star shaped scar. In distemper there is a doughy swelling between the branches of the lower jaw, which is hot and painful and interferes with the swallowing and causes the horse to carry his head forward. This swelling has a tendency to soften, break and discharge pus; while in glanders the swelling along the lower jaw is painless and the swollen glands remain distinct and cord-like. Also, in testing with mallein the glandered horse has a large, painful swelling at the point of injection of the mallein, which will not occur in the animal with distemper.

Prevention: All glandered animals should be immediately destroyed and not allowed to come in contact with healthy animals through stables, common drinking troughs, harness, or any other stable equipment. All suspicious animals should be isolated and cared for independently of healthy animals, until examined by a competent veterinarian. Infected buildings should be disinfected with one to five hundred corrosive sublimate solution, and a week later the process repeated. Then in two weeks after the second disinfection all woodwork should be whitewashed. Forage and litter in infected stalls should be burned. Attendants caring for suspicious animals should exercise precaution against contracting the disease.

Glanders is practically an incurable disease, therefore it is not advisable to treat it.

In doubtful cases of glanders, the *mallein test* is given. This test should only be given by a qualified veterinarian and until it is satisfactorily determined whether a suspicious case is, or is not glanders, the animal should be kept apart from all other horses or mules. Remember that the disease is occasionally transmitted to the human and is incurable in man or beast.

Foot and Mouth Disease.

By Dr. B. F. Kaupp.

Foot and mouth disease has made its appearance in the United States twice during the past ten years. The first time in 1902, an unexpected outbreak occured in Massachusetts, Rhode Island, New Hampshire, and Vermont. By prompt action of the U. S. Department of Agriculture, Bureau of Animal Industry, this outbreak was quickly stamped out. All animals found affected were destroyed and either burned or buried deeply in the earth after first covering with lime.

Recently the disease has been discovered in a much wider district involving Maryland, Pennsylvania, New York and Michigan. By strict quarantine, the destruction of all animals found affected and by thorough disinfection it is hoped that the disease will be entirely eradicated.

It is necessary that this country be kept free from Foot and Mouth disease as otherwise an embargo will be placed upon American cattle, thus a great financial loss to the stock producing West.

In European countries where the disease has existed for a long time, the number of animals that die from this disease is only about

five percent. The greatest loss is as follows: In dairy cows the owners suffer the loss of milk from four to six weeks. Cattle lose flesh, due to high fever, and inability to eat, due to the fact that the sores and vesicles (water sacs) in the mouth make it impossible for them to eat. Owners can not dispose of the sick animals.

After the animal has been exposed to the disease for about one week it will be taken by a chill which is followed by fever. In about two or three days small vesicles (water sacs) will be noticed in the mouth, on the borders of the lips and tongue. These vesicles contain a yellowish thin fluid. The redness about the feet which is followed by the formation of vesicles like those in the mouth takes place soon after the formation of those in the mouth. Thick saliva dribbles in rope-like strings from the mouth.

Animals which have recovered from the acute attack are found to be seriously injured. Many of them will lose the hoofs from their feet. Others are chronically lame. Abscesses may form in the udders of cows giving milk. Pregnant cows may abort. Many are so injured constitutionally that they become emanciated and of no value.

In conclusion we may consider that while the loss from death due to the acute attack is perhaps only five per cent, the total loss in death, loss in milk, loss to fattening cattle, etc., will amount to perhaps close to fifty percent.

The only thing is to keep the disease out of the United States. Prompt action by the Federal Authorities who control interstate commerce, destruction of the animals, thorough disinfection, and strict quarantine are the only sane measures.

Hog Cholera.

By Dr. B. F. Kaupp.

The losses from hog cholera in the various states amounts to many millions of dollars annually. The spread of contagious diseases through the central stock yards and by cars and boats not disinfected, a condition which existed prior to the establishment of inspection by the Federal Bureau of Animal Industry, resulted in the contagious diseases existing in this country, (among them hog cholera) becoming wide spread.

The real germ of hog cholera is a microscopic organism which passes through the finest of filters, a germ which has not been discovered. We either have not discovered a suitable staining fluid or our microscopes are not powerful enough to see it. This filtrate from which all other germs have been taken out produces the disease.

The Bacillus Cholerae Suis or the secondary invader producing this disease collect in the capillaries of minute blood vessels and these rupture, cause a small red or hemorrhagic spot. Upon examination after death these small hemorrhages are found in the kidneys, over the outer surface of the bowels and inner surface of the abdomen and thorax, etc. An observation of the skin shows red patches due to small hemorrhages into it. In young hogs the spleen (melt) is

often noted to be inflamed, (splenitis), it often is three or four times its normal size. The fat is somewhat of a lemon yellow. The lymph glands (kernels) are noted to be swollen and hemorrhages in them. Pneumonia may be present. The bone is black. When the small intestines are opened ulcers are found on the inner surface.

Symptoms: In the more severe cases the animal may die in a very few hours after the first symptoms are noted.

If the disease in the individual assumes a milder type there is first seen signs of fever, chill, not caring to move, will lie apart from the balance of the herd. There will be a loss of appetite, the bowels may be normal, or constipated, or diarrhea may be present. If pneumonia is present there will be noted an increase in respiration. The eyes are congested in the earlier stages, later a watery discharge and a gummy, adhesive yellowish or whitish accumulation in the corners of the eyes. The animal may cough, is now tucked up in the flanks and has a jerky respiration commonly called "thumps."

Treatment: The first measures should be a thorough cleaning up of the houses and yards. The hog troughs should be kept thoroughly clean and disinfected. The task of thoroughly disinfecting the hog houses, yards, troughs and fences is not an easy one but the free use of a spray gun with five per cent carbolic acid, bichloride of mercury one dram to each gallon of water, or creolin one per cent will do much good in the way of disinfection.

Medicines which are given by the mouth or in the feed are of little or no value. Many so-called "hog cholera cures" are put on the market, but they are fakes pure and simple. It is an easy matter to get testimonials. Passification of the mind may do as a "placebo" but if the hogs get cholera they will need something other than talk. There is one method of producing immunity against hog cholera and that is by serum injection. For many years after the discovery of the bacillus cholerae suis the manufacture of hog cholera serum was attempted by the United States Department of Agriculture through its Bureau of Animal Industry.

This serum is made by hyperimmunizing the hog by taking a hog that has passed through the disease and injecting this pig with a quantity of virus from a hog sick with cholera and in this way producing in this hog a greater resistance, and as a result the serum from the blood of this hyperimmunized hog will produce a greater resistance against the disease in another individual and make it proof against cholera.

The Bureau of Animal Industry has been conducting extensive experiments along this line in Iowa for several years and have perfected this method of treatment. They have asked the Experiment Stations of the various States to cooperate by establishing the hog cholera experiments departments upon their farm so as to manufacture and furnish at a minimum cost all serum needed within the State. The serum perhaps costs a trifle more than those serums which can be produced by using the horse as the hog does not furnish a great deal of blood.

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SOME BACTERIAL DISEASES OF PLANTS

[Information Bulletin]

BY

WALTER G. SACKETT

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SOME BACTERIAL DISEASES OF PLANTS

By WALTER G. SACKETT

FOREWORD

It is the purpose of this bulletin to call attention to some of the more common bacterial diseases of plants which are either present in the State or may be expected in the future, with the hope that the old adage, "To be forewarned is to be forearmed," may be of some avail. With one exception, the diseases here treated are well known in the Eastern and Central States, where they have caused immense losses to gardeners and fruit growers. Where remedies are known, they have been suggested, but it is the deep regret of the plant pathologist that for the majority of bacterial diseases no efficient treatments have been discovered and prevention is the only hope.

While the climatic conditions of Colorado may be said to be on the whole unfavorable to the development of diseases in plants, especially fungus troubles, the fact remains that there are some localities which have suffered heavily from causes traceable to bacteria. Nature has blessed this State with conditions which afford all that could be desired toward the natural prevention of bacterial diseases; the dry air, the limited amount of rainfall and the abundance of sunshine, all combine against the growth of germs.

The soil of Colorado is comparatively new so far as agricultural practices are concerned, and with the change in its character and fertility, brought about by continued cropping, we shall expect to find many of our cultivated plants becoming more and more susceptible to the attacks of microorganisms.

With the introduction of new plants, new varieties of old plants, foreign seeds, and strange nursery stock, it is not at all improbable that previously unheard of diseases will make their appearance.

Again, as the farming communities become more thickly populated and more new land is cleared and brought under cultivation, the danger of plant diseases spreading from farm to farm is greatly increased.

Plants and trees, like human beings and the lower animals, are affected with contagious diseases which spread from individual to individual, from field to field, and from ranch to ranch in precisely the same manner as any contagion is communicated from one member of a family to another. The more densely a city is populated, the greater is the danger from the spread of disease and the more stringent must be the laws which govern the sanitation of

that city. Quarantine must be established or an epidemic is sure to follow. Just so with diseases in our fields. It should behoove every farmer to see to it that his field is free from infection and to compel his neighbor to be equally vigilant.

The diseases treated are:

BACTERIAL DISEASE OF ALFALFA

PRELIMINARY REPORT.

In November 1906, Prof. Paddock* called attention to an alfalfa disease occuring in certain parts of Colorado, which was different from any previously desciibed malady, and which, from all appearances, was not related to either leaf spot or mildew. Gross examination of the affected stems and roots and subsequent microscopic examination satisfied him that in all probability the disease was of bacterial origin. During the past summer, 1908, a careful study of the disease has been undertaken both with field and laboratory studies, and a technical bulletin is now in preparation, describing both the diseases and the causal organism. Our present investigations have confirmed the preliminary work of Prof. Paddock and have shown the cause of the disease to be due to a germ of the bacillus type.

DESCRIPTION OF THE DISEASE.—At a distance, the disease can be recognized by the short, sickly growth of the first crop and the marked absence of that rich, deep green color and succulent appearance of a thrifty stand. Many of the plants do not get over eight inches to a foot high by the time of the first cutting. A close examination of the stems shows them to be shriveled and blackened for two to three inches up from the ground. The infection seems to attack the plants next to the soil and to work up the stem. As the disease progresses, it produces a watery, semi-transparent, brownish appearance of the tissue which turns black with age. By running the thumb nail along the stem, it is possible to scrape up under the delicate surface skin a little yellowish, watery blister, the content of which is a sticky, stringy liquid, yellow in color, and alive with bacteria. This liquid frequently oozes out on the stems

*Press Bull. 28, Colo. Expt. Sta.

in little bead-like droplets and there hardens into small, amber-colored scales. Again it appears to dry uniformly over the surface, or just beneath it, and there produces a dark brown, resinous surface, which blackens with age. Such stems are very brittle and easily broken, which fact makes it almost impossible to handle the crop without an immense amount of shattering.

The leaves attached to the diseased part of the stem usually show the watery, yellow color at the base and especially in their tiny petioles. The leaves on those parts of the stem which are blackened are always dried up, yellow, and extremely brittle. The stipules at the base of the petioles are yellow and brittle, and show the disease before their corresponding leaves.

One year old plants exhibit blackened areas in the crown and black streaks running down into the tap root. As the plant grows older this blackening increases until the whole crown is involved, and either the crown buds are destroyed or the root is no longer able to perform its functions, and death follows.

So far as our present observations go, the disease appears to run its course with the first cutting, and those plants which have sufficient vitality throw out a good growth for the second and third cutting. Strange as it may seem, there is little or no trace of the blight during the remainder of the season, but in the following spring an aggravated outbreak may be expected. The disease apparently does not kill many plants the first year, but they begin to die after the blight has been prevalent more than one season, and after two or three years so many of them may be missing that the stand is practically worthless.

At present, we are at a loss to explain satisfactorily why the first cutting, only, should be attacked, unless it is that by pasturing cattle on the alfalfa field during the winter, the constant tramping splits open the crowns and bruises the young, tender shoots so that during the first irrigation, soil containing the disease germs is washed into this injured tissue. The weather conditions at this time of the year are, as a rule, unfavorable to a rapid, vigorous growth of the plant, and it is probably in a hyper-susceptible condition. This explanation is borne out, first, by the fact that the disease has not been observed to occur until after the first irrigation; and second, by the fact that since no cattle are allowed in the field after the first cutting, the young crown buds of the second crop have received no mechanical injuries through which they might become inoculated. Again, the plants themselves are in a more vigorous, resistant condition at this season of the year.

Future experiments alone will demonstrate whether it will be possible to prevent the disease upon the first cutting by keeping stock off the land during the winter and early spring, and by so doing

eliminate mechanical injury to the plants during the susceptible period.

Inasmuch as the disease seems to be clearly a soil trouble, the only practical method of controlling it is by the introduction of resistant varieties. To this end we have planted some twenty-seven different varieties of alfalfa on sick land with the hope of obtaining one or more blight resistant strains. This side of the work was begun by Prof. Paddock two years ago, and after two years' trial under field conditions, we have obtained some very promising results with two of the varieties tested. Whether these will continue in their resistance during the next few years remains to be seen.

PEAR BLIGHT. (*Fire Blight*)

A description of Pear Blight may seem uncalled for to the fruit grower who is sufficiently familiar with the malady to recognize it at first sight and to whom the mere suggestion of the name recalls immense financial losses, but to the farmer, who has three or four trees around his house for his own use and who has not had his attention called to the disease in such a material way, some consideration of the subject may be given with profit. Not only should the farmer become acquainted with the symptoms of the disease and learn and practice methods of prevention and eradication for the sake of his own trees, but also for the sake of his neighbor's orchard as well. One infected tree in the community may mean the ultimate loss of vast orchards for miles around.

Of all the diseases which affect our fruit trees, there is none, perhaps, which is so universally dreaded by the orchardist as the pear blight. While the ravages of the disease are worst upon the pear, from which fact the disease derives its name, its attacks are not confined in any sense of the word to this tree alone. Many varieties of the apple, quince, apricot and plum, together with the mountain ash, service berry and several species of hawthorne, have suffered severely from the same cause. Especial attention should be called to the part which such ornamental trees as the mountain ash and hawthorne play in harboring the germs of blight. If these trees become infected and are allowed to go unnoticed, it is obvious that it is useless to attempt to stamp out the disease in adjacent fruit trees or a nearby orchard, since a constant supply of germs will be furnished by the ornamental plants mentioned, with which to reinfect the fruit trees. If such conditions are found to exist, but one thing remains to de done—remove the offending individual bodily and burn it.

The name *fire blight* is especially good because it is at once suggestive of the symptoms of the malady. To one not familiar with the disease, it can be recognized at first sight by the brown and

subsequent blackened appearance of the young leaf tufts and flower clusters; some of the leaves may be only partly blackened, while the greater part of the blade remains green; the young twigs show a blackened, shrivelled bark, resembling very much green brush which has been only partially burned. The blight makes its appearance early in the spring shortly after the blossoms have fallen and works rapidly back from the blossom clusters an inch or more a day. It soon involves the tender, succulent twigs and may ultimately destroy the whole limb. If the diseased wood be cut with a sharp knife, a dark ring between the bark and the wood will usually be seen. This is a further indication that the tree is affected. This ring of tissue, now blackened, is known as the *cambium layer*. It is here that a rich and abundant supply of food is to be had and, quite naturally, what is good for the growth and development of the tree is equally as nourishing for the germs. So we find, upon microscopic examination, that this blackened cambium tissue has lost its normal color and appearance and instead of the cells being almost white in color with a clear, colorless liquid within, they are brownish, more or less broken, and all through this mass of broken down tissue is a straw-colored liquid, clouded with millions upon millions of germs. These germs is growing here have dissolved out the starchy constituents of the plant tissue and literally eaten up the cells to such an extent that the circulation of the plant is destroyed. The rapid progress which the disease makes is to be accounted for, in a measure at least, by the fact that the causal microorganisms have the power of very rapid movement; that is, we say they are motile. Thus endowed, they are persistently swimming about in the protoplasm of the cambium, dissolving and boring their way into new, healthy tissue where a fresh supply of food can be obtained. As the disease progresses and the smaller limbs show the infection, the tender bark may crack and a thick, black, sticky gum, alive with germs, may exude; soon afterwards the bark becomes dark colored, hardened and shrunken.

The disease makes its greatest progress during the actively growing period in the spring when the tree is putting forth a multitude of young, tender twigs and the new tissues are gorged with sap. Just such conditions as these favor the growth of the blight microorganisms, so it is easy to see why the disease is worst at this time of the year. As the season advances, the plant tissues harden, less sap is flowing, and conditions for germ life become less favorable. As a result, by the middle of summer the active progress of the blight is checked by natural causes, but the disease is still present in what may be termed a latent form. In this stage it sometimes remains through the balance of the season and, protected by the bark of the twig or limb, it may live through the winter, giving

rise to what is known as holdover blight. It is the germs which exist in this holdover blight which serve to reinfect the orchard the following spring. In most instances, however, the germs die out of their own accord during the winter and leave the whole tree or portions of it free from the infection of the previous season. Although the disease is usually at its best in the early spring, the writer has in mind an orchard in Central Ohio, numbering some four hundred trees, in which the blight assumed its most severe form about three weeks previous to picking the fruit. Up to the middle of August there were but three or four badly infected trees, and within three weeks from that time, every tree in the orchard was suffering from a severe attack. The fruit had to be picked two weeks before time in order to prevent all from being ruined by the blight.

Pear blight is variously known as pear blight, apple blight, fire blight, twig blight, blossom blight, and body blight, the name depending upon the species and portion of the tree affected. If the blight attacks the larger branches and trunk where there has been some bruise or mechanical injury, the symptoms are much the same as what is known as sun burn or sun scald. This form of the malady is known as rough bark or body blight.

It is only within comparatively recent years that we have known that the cause of apricot and plum blight is the same as that of pear blight. Prof. Paddock,* in describing the disease as it occurs on the apricot, says:

"At this time many of the fruits were attacked, the diseased areas varying in size from a spot an eighth of an inch in diameter to irregular areas that involved three-fourths of the fruit. The skin over these places soon became nearly black in color and shrunken as the tissues were consumed till the outline of the pit was disclosed. These discolored areas were always definitely outlined and bordered with a zone of watery appearing tissue usually about an eighth of an inch in width. The latter was green in color and as hard as the sound flesh.

"The smaller spots where the disease had evidently just started, invariably surrounded a lenticle; thus indicating that the disease gained entrance to the fruit through these openings.

"The injury to the twigs may be described best by saying, that they resembled closely, blighting pear or apple twigs. So far as noticed only tender twigs of the current season's growth were attacked. These were shrivelled and discolored from a few to several inches in length, and small drops of sticky fluid were occasionally found on their surface and upon the shrivelling leaf-stems. The discolored outer bark blended gradually into normal appearing tissue, but the inner bark was discolored for some distance below any external evidence of disease."

HISTORY.—The disease is by no means recent, for it dates back to the time of William Denning, who first reported the trouble from the Highlands of the Hudson in 1770. He described it fairly well and ascribed the cause to a borer in the trunk of the tree.

The oldest book on American Fruit Culture, published in 1817

*Bull. 84, Colo. Expt. Sta.

by William Coxe, gives a very accurate description of the disease. From this early date up to comparatively recent times, horticultural literature has been crowded with numerous extravagant theories of the cause of the blight. Even today we occasionally find men who hold to one or another of the old ideas. It may be interesting to know what some of these were:

1. Insects.
2. Rays of the sun passing through vapor.
3. Poor soil.
4. Violent changes in the temperature of the air or the moisture of the soil.
5. Sudden change from sod to high tillage, resulting in surplus of sap.
6. Effect of age.
7. Autumn freezing of unripe wood, which makes a poison destroying the shoots and branches the following spring.
8. Electricity in the atmosphere.
10. Fermentation of sap.
11. Absence of certain mineral matters in the soil.
12. Something in the air which is carried from place to place.
13. Fungi.

ORIGIN AND SPREAD.—In 1878, Prof. W. T. Burril, of the University of Illinois, succeeded in finding a kind of bacteria which he believed to be responsible for the disease.

The blackened twigs and sticky exudate were found to be alive with germs, which are very small plants, so small, in fact, as to be seen only with a very powerful magnifying glass such as we find in the compound microscope. Some idea of the size can be gotten when we know that it would require 25,000 germs placed end to end to make one inch.

By taking some of this gummy material, which contains the bacteria, and inserting it into a healthy twig through a small cut, it was demonstrated that the inoculated twig took the disease and that therefore it could be spread from one tree to another, or was what we call an infectious disease. It was also shown that this same gummy material from the pear could produce the disease on the quince and the apple. This experiment is very simple and can be tried by anyone who is interested in the infectious nature of the blight. It was argued by some that it was not the germs which produced the blight, but rather the gum which was injected. To meet this objection, the germs were grown in a suitable medium such as beef broth and a quantity of the pure organisms were inoculated into a healthy twig. The results were very conclusive, for the twig soon died, showing that the germs by themselves had the power of killing the plant.

The question which we now have to answer is, where does the blight originate when our orchards have never had it before? Where does it come from? It has been shown quite conclusively that it is

not carried on the wind, neither is it traceable to the soil. Ants, flies, and possibly bees may feed on the gummy material which runs out from the cracks in the diseased wood, and knowing that this exudate contains millions of germs, it is only reasonable to believe that these insects carry the disease on their feet and bodies to the healthy trees. Alighting on a delicate flower cluster, they crawl deep down after the so-called honey or nectar in the blossom and here many of the blight germs are brushed off and left in contact with the tender blossom. Through these honey ducts or nectaries the bacteria gain entrance to the plant. Once favorably situated, they multiply and move down the twig between the bark and woody cylinder through the growing layer. It is in this way that a large percentage of the cases originate. As further evidence of this method of infection, we may cite the investigations of Mr. M. B. Waite, of the U. S. Department of Agriculture, who found the germs developing in the nectar of the blossoms and also discovered them adhering to the mouth parts of honey bees after they had visited infected flowers. He further observed that, in many cases, trees which did not blossom were free from blight.

Again, the germs may gain entrance into the tender shoots through insect bites in the bark, for, although the opening may be no larger than a pin prick, myraids of bacteria can find a temporary dwelling place in this wound and may soon spread through the whole member. Lastly, the infection may enter the large limbs and trunk of the tree by some scratch or bruise in the protecting bark which has exposed the susceptible growing layer beneath to the visits of germ-laden insects.

Thus we see that pear blight is caused by a germ to which the name *Bacillus amylovorus* (Burrill) has been given, the meaning of which is starch destroying. We see that it is spread from one tree to another by different insects, and that the germs may gain entrance into the plant in any of three ways: First, and most important, through the blossom; second, through insect bites in the tender shoots; third, through mechanical injuries to the bark of the limbs and trunks of the trees.

CONDITIONS FAVORING THE DISEASE.—Although the knife is our only hope of exterminating the blight, there are undoubtedly conditions which favor the disease.

It is a matter of common observation that climatic conditions have a marked influence; warm, moist weather with a large amount of rainfall favors it, while bright, dry, cool weather tends to check it. That is, the former conditions are advantageous to the growth of the germs, while the latter are unfavorable.

High cultivation, rich soil, heavy manuring, the use of large

quantities of commercial fertilizers containing a great deal of nitrogenous material and heavy pruning all tend toward the growth of tender, succulent shoots. It is in this sort of plant tissues, gorged with sap, that the blight germs can grow and multiply most rapidly. Biting insects whose mouth parts are contaminated with the causal microbes, are most partial to these juicy shoots and leaves, and their bites often serve to infect the tree.

It is evident, then, that vigorous, healthy, rapidly growing, too well cared for orchards are more liable to the disease than others, and since these are factors which the grower can control, it is he who must strike the happy medium which will not permit the trees to suffer and yet will not give ideal conditions for the development of the germs.

PREVENTION AND TREATMENT.—The treatment of fire blight is of two kinds—the one, preventative, which aims at making the tree resistant to the attacks of the disease; the other, curative, which is intended to exterminate the harmful microbes and thus prevent their spread.

1. It is obvious, if we are to render our trees resistant to blight, we must avoid those conditions which increase the predisposition to the disease. We have already mentioned the most potent factors in the propagation of blight as high cultivation, rich manures, commercial fertilizer high in nitrogenous material, excessive soil moisture, and high pruning. In short, anything which favors the rapid growth of tender, succulent shoots should not be practiced. It is understood, of course, that these suggestions are not to be followed without reason, or the trees will suffer from troubles other than the blight. The trees should be allowed to ripen their wood, and to this end the grower must use some means which will limit the moisture in the soil. It is recommended that some good cover crop, such as oats, be used for this purpose in localities where the necessary moisture is supplied by rain and where the growing period is apt to be prolonged into the late summer because of excessive soil moisture.

In irrigated regions, where the water is entirely under the control of the grower, the problem of ripening the wood and preventing late succulent growth is a comparatively simple one. Good results have been obtained in eradicating blight from afflicted orchards by withholding water altogether for long periods and also by limiting the amount supplied to the minimum necessary to keep the trees alive.

Prof. Paddock* gives the following account of an orchard suffering with pear blight, which had not received any water for two

*Unpublished Notes

and a half years and which illustrates in a practical way what the withholding of water has done toward the eradication of the disease in a natural way:

"The writer had an opportunity of studying an orchard during the summer of 1904, which had been without water for two and one-half years. The effect of this enforced drought on checking blight was very marked, and it also showed that pear trees can exist in this location for a considerable period without irrigation or cultivation. These results would probably be the same in all of the pear growing sections of Colorado. * * * * At the time of my visit, June 25, 1904, many of the trees were still in good condition. This was especially true of the Winesap apple. The Jonathan trees were still in condition to be saved, but they were less vigorous than the Winesaps. Most of the Ben Davis trees were still alive, but the majority of them had put forth few or no leaves. About one-half of all of the apple trees of all varieties were dead, as well as most of the peach and plum trees.

"But the most remarkable, was the appearance of a block of eight-year-old Bartlett pear trees. Most of them were still in a fairly vigorous condition. Some of the twigs of the previous season's growth measured fourteen inches in length. The average of the current season's growth was about four inches, and quite a little fruit had set on some of the trees.

"The inspector, Mr. H. E. Mathews, had visited the orchard each season and he found that in 1902, blight was quite abundant in the pear trees and some of them died from its attacks. The following year there was still a good deal of blight, though there was much less damage than before. At the time of my visit, June 25, 1904, there were but few twigs in which the disease had been active that season and the germs were apparently dead. * * * * These results show that the germs of blight do not thrive in slowly growing trees and, in fact, that the disease may be eradicated by prolonged drought. They also show that pear trees will remain in good condition for a considerable period without irrigation or cultivation. But just how far this could be carried in actual pratice remains to be seen, but one cannot help but surmise that bearing pear orchards might be successfully handled without irrigation, depending upon cultivation, or lack of it to regulate the water supply."

2. With a disease working as this does in the juicy part of the stem between the bark and the wood, there is no chance of reaching the trouble by means of sprays, for, unless the chemicals come in contact with the bacteria, spraying is futile.

The knife and saw remain as the only effective remedies. We must cut out and burn all affected twigs, leaves and branches, not only from the pear but the apple, quince and related species as well, so that there will be no infectious material near by for insects to carry into the blight-free orchard. It is very essential in cutting out the diseased branches to cut well below the discolored part, as the bacteria are usually far below this region. The discoloration does not appear until after the bacteria have been at work some time, so that even if all the blackened wood were removed the seat of the trouble would not have been reached, and the germs would live on in the apparently healthy stump, soon to cause another visible outbreak of the blight. The affected branches should be cut back all the way from ten to fifteen inches below the discolored wood, and if the branch be a large one, more than one-half inch in diameter,

the cut surface should be protected from wound rots by painting. Either lead and oil paint, or shellac wash, or grafting wax may be used for this, but the lead and oil paint is cheaper and less liable to crack than the others when exposed to the sun. The question may be asked, "When is the proper time to do the cutting?" The writer would answer, "Whenever the blight appears." Trimming out the diseased parts may be done at any time in the late fall, winter and spring. The most favorable time, however, is in the autumn after the leaves have fallen, for then the blighted twigs become very conspicuous by the dead leaves still hanging to them. It is not advisable to postpone the cutting until the growing season, for at that time there is great danger of overlooking new cases which are constantly occurring owing to the lack of development so early in the season. If the entire tree is affected, there is little hope of saving it and the best procedure is to grub it out and burn the whole tree. Too much stress cannot be laid upon the complete destruction of the diseased wood, for our only hope of stamping out the blight lies in removing the source of the infection. A single twig left on the ground unburned may mean the loss of the whole orchard.

The knife and the saw used must be sterilized after each cut in order that the disease germs clinging to the instrument may not be carried to the healthy parts of the tree. This can be done by passing the knife several times through a flame, or it may be dipped into either a 5 per cent. solution of carbolic acid or a 1-1000 solution of mercuric chlorid, made by dissolving 1 part by weight of mercuric chloride in 1,000 parts of water to which 2 parts of hydrochloric acid have been added.

A careful inspection of the orchard should be made in the winter and spring before the blossom season, in order to destroy any new cases that may have developed since the previous examination.

The greater part of the blight will be eradicated by one careful winter and spring cutting, and if this be done and done thoroughly, the disease can be entirely controlled.

SUSCEPTIBILITY OF DIFFERENT VARITIES.—So far as we know at the present time there are no varieties that are entirely immune to the disease. Mr. O. B. Whipple, in charge of the fruit investigations of the Colorado Experiment Station on the Western Slope, state that among the pears grown in that locality, the Bartlett, Easter, Flemish Beauty, Clapp's Favorite, Clairgeau, Howell, and Sheldon suffer worst from the blight, and among the more resistant varieties may be mentioned the Anjou, Kieffer, Seckel, Mt. Vernon, Garber and Suduth. The most susceptible apples found in this same region are the Tolman Sweet, Peewaukee, Transcendent (Crab), Jonathan, Red Mountain, and Winter Banana.

Among the apples, the crabs in every case seem to take the disease most readily, but even here there are some which are freer from blight than others. It has been observed that the same variety in different localities and under different climatic conditions will exhibit different degrees of resistance. An earlier publication of the Colorado Experiment Station* cites one case in a certain locality where Martha and Whitney crabs were grown alternately. The Whitney trees were either all dead or dying, while not one of the Marthas was affected. However, in other localities the Marthas had succumbed to the blight.

In selecting trees we should be guided by local experience and choose the varieties which have done best in our locality.

SOFT ROT OF THE SUGAR BEET.

Although this disease has not yet been reported in this State, it is not at all improbable that it will make its appearance in due time as the acreage put out to sugar beets increases from year to year. The soft rot, as it occurs in Nebraska, was first observed in 1902 by Metcalf and Hedcock,† who have isolated the specific germ *Bacterium teutlium* (Metcalf), which is the cause of the trouble. Beets affected with the rot show the lower half badly decayed and the rotting part honeycombed with "pockets," or cavities filled with a slimy, stringy fluid, colorless and sour smelling. The vascular bundles remain intact, while the tissue surrounding them is usually consumed. The normal color of the beets differs so that it is difficult to give any hard and fast color characteristic, but when affected the tissue first shows a yellow, changing to a clay color or gray; later these colors gradually darken. In some cases beets that are badly rotted show no discoloration, while others in the early stages are very dark. Above ground the beets appear normal.

A microscopic examination of viscid liquid that fills the cavities of the rotting tissue shows millions of bacteria, which when grown later in pure culture and inoculated into healthy beets produced symptoms typical of the disease.

The germs gain entrance into the beet through wounds and abrasions in the skin, and there is good reason for believing that nematodes are responsible for many of the inoculations. So far as experimental work goes, there is no evidence that infection can take place, except through cuts or scratches in the outer surface of the root. In the field, the disease has been observed to progress most rapidly under warm and wet conditions; more mature beets are affected more severely than the younger ones, probably due to the larger amount of sugar present.

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*Bull. 41, Colo. Expt. Sta.

†17th Annual Report Neb. Expt. Sta.

If the beets are stored in silos and rotting sets in, they should all be inspected and the decayed ones put in a pile by themselves, so that all will not contract the rot. Cold storage does not seem to have any influence on checking the trouble, for even at low temperatures the germs continue to grow and produce havoc. It is recommended that beets from sick soil be thoroughly sunned and dried before storing, inasmuch as the dessication and sunlight have been found to be very detrimental to the growth of the germs.

Prevention is the only remedy that can be suggested at this time. Grow beets on relatively dry ground, if possible, and plant corn or some other suitable crop on former beet ground where the excess of moisture can do no harm. Our greatest hope of controlling this disease, as well as others, is by breeding up some resistant variety and, by careful selections, secure a strain which can be planted on wet land and yet remain immune. There is no question but that such resistant varieties will be forthcoming in the near future now that the scientific world is so wide awake to the wonders of plant breeding.

BLACK ROT OF CABBAGE.

The black rot of cabbage is to the truck producer what pear blight is to the fruit grower; in fact, it may be considered far worse, for on the one hand there is only the loss of the crop, while on the other, not only is the cabbage destroyed, but, in addition, the soil on which it has been grown may be so inoculated that it will be practically useless to attempt to raise the same crop on the same field with any degree of success for a number of years. While this condition of the soil exists almost universally in the East, there seem to be exceptions to it in this State, since Prof. Paddock reports that in certain localities in Colorado he has grown cabbage successfully on land which was badly infected the previous season.

Bacterial examination of diseased plants has shown the sickness to be due to a kind of germ, *Pseudomonas campestris* (Pammel, Smith). The disease is by no means confined to the cabbage, but attacks other cruciferous plants such as cauliflower, collards, kohl rabbi, kale, brussels sprouts and broccoli. It has also been reported as occurring in turnips, rutabagas, wild radish and mustard. It is widely distributed in the United States, having been found most prevalent east of the Mississippi River. In 1901, Prof. W. Paddock reported it from Colorado. Previous to 1899, we do not hear of the black rot in Europe, but the investigations of Harding,* confirmed by foreign workers, show the disease to be wide spread and of long standing. England, Holland, Denmark, Austria and Switzerland are mentioned as constant sufferers from the malady. This

*Cent. f. Bakt. II Abt. Bd. VI., pp. 305-313 (1900).

is peculiarly interesting, since a few years back a great deal of our cabbage seed was imported from Holland and Denmark. The comparatively recent discovery of the infection in Europe is probably due to the better methods of diagnosing the disease than formerly, rather than to recent appearances of the trouble. Cabbage growers of Europe have observed it for many years, it seems, but they were accustomed to associate the cabbage worm with the rot, rather than the true bacterial cause.

The disease can be recognized by the dwarfed, one-sided growth of the plants and in some cases, failure to produce heads. Sometimes the head will rot and fall off, but this is not a necessary accomplishment of the disease, for this symptom, together with the bad smelling head, may be due to the work of other bacteria which are living on the tissue already weakened by the true black rot organism. In the early stage of the disease, the leaves show a withered, dried appearance along the margin, followed. in time, by a yellowing. The small ribs that lead to the mid-rib are usually blackened first, and ultimately the larger ones and the mid-rib succumb. On cutting across the stem of an infected leaf or sick stalk, one can see the blackened ends of the fibrous strands, known as the fibro vascular bundles, which lead from the stalk out into the leaf and supply it with water and soil foods. A microscopic examination of these vascular bundles will show the tiny tubes of which they are composed to be alive with germs. As soon as these foods and water channels are destroyed, the blade of the leaf is no longer able to get the subsistance required and dies. Diseased leaves usually fall prematurely, leaving a long, naked stalk with a tuft of leaves at the tip. The old leaf scars will show the ends of blackened strands corresponding to the diseased fibro vascular bundles in the leaf.

It has been found* that the most common method of infection in the field is through the very small water pores scattered over the blunt teeth on the margin of the leaf. It is by these water pores that a part of the soil moisture that is taken up by the root system escapes from the plant as water vapor, but if the surrounding atmosphere is very moist, there will be no evaporation and the water will be seen to accumulate in tiny droplets just over the pores. However, if the soil is very dry, even though the air is moist, we do not have these water beads formed. They can be seen frequently in the early morning on the surface of the leaves and are frequently mistaken for dew. It must be borne in mind that the air is always filled with dust and numerous bacteria, and among these there are almost certain to be the germs of black rot, especially if

*Russel—Bull. 65, Wis. Expt. Sta. Farmers' Bull. 63, U. S. Dept. Ag.

the wind is blowing over a sick field carrying with it fragments of rotting plants and infected soil. These germs are in the beads of moisture, referred to above, and finding a comfortable lodging place and abundant food and water supply, they multiply very rapidly, and being able to move about, soon find their way down through the water pores into the veins of the plant. Here they continue to multiply and work toward the stalk, leaving behind them the blackened veins and withered blades. The germs may also gain entrance by means of the bites of gnawing insects and again by way of the broken roots at the time of transplanting.

There is no question but that in many cases the plants are taken from the seed bed in a diseased condition and when transplanted into the field spread the germs through the soil, rendering it unfit for cabbage growing in the future. When the source of the infection is confined to such a limtied space as the seed bed, it is possible to sterilize the soil to a depth of five or six inches by covering it with brush and cord wood and burning it, the heat produced penetrating sufficiently deep to kill most of the surface bacteria, as well as troublesome weed seeds. This is a very common practice with tobacco growers and has met with great success wherever employed. If this is not practicable, the seed bed should be located in a new place each year and where cabbage has never been grown. It is only reasonable to suppose if plants are in a good, vigorous condition when transplanted into a "healthful" field, their chance of living is vastly greater than if sick from the start.

When stable manure is used for fertilizer, every precaution should be taken to keep infected cabbage refuse from getting into the manure, for in this way the whole heap will become infected with the rot germs and when it is spread on the field the entire plat will become inoculated. One of the worst plant disease epidemics on record was caused in this very way. The writer refers to the present watermelon wilt in North Carolina, South Carolina, and Georgia, where melon growing for the past six years has been practically abandoned by the smaller producers because of the ravages of the wilt. The only safe way to dispose of refuse is to burn it.

It has been demonstrated experimentally by Harding,* Stewart, and Prucha that the cabbage seed itself is contaminated with the black rot germs and that some of them could live over winter on the seed and become the source of infection to the young cabbage plants. They advise disinfecting the seed before sowing by soaking it in a 1-1000 solution of corrosive sublimate† for fifteen minutes.

*Bull. 251, N. Y. Expt. Sta.

†Corrosive sublimate. See preparation of mercuric chloride described under Pear Blight.

or in formalin, one pound in thirty gallons.

The removal of sick leaves in the early stages of the disease is practiced by some growers with success. Others have tried this preventative and found it to be a complete failure. The investigations of Stewart* and Harding condemn this practice and prove quite conclusively that the method is not only harmful to the plants, but also worthless. The treatment fails, they say, because,

"The removal of so many leaves checks the growth of the plants; infection occurs by way of the roots as well as through the leaves; infection may occur at the base of the leaf close to the stem and get into the stem unobserved; the germs of the disease are so widely and so abundantly distributed that it is useless to try to stamp out the disease by the removal of diseased material."

Warm days, cool nights and frequent showers seem to accelerate the rot. Smith† is inclined to think that cabbage planted late is less susceptible than that which is planted early. In selecting cabbage for producing seed the following season, care should be taken to pick out only those plants which are absolutely free from the infection.

When cabbage is to be stored over winter, the heads should be examined critically and any diseased ones rejected or kept by themselves. The room or store house must be kept cool, below 40° F., and must have uniform ventilation.

It is a matter of common observation in the Eastern States that when cabbage is grown year after year on the same piece of land, there is a notable increase in the amount of rot. In the first place, such a method is not to be recommended from an agricultural standpoint, since it violates the important principle of crop rotation, and further, if it becomes necessary, because of limited space, to continue using this land, our only hope of getting rid of the disease is to grow crops other than members of the cabbage family for five or ten years and longer. During this interim the land must be kept free from all cruciferous weeds which harbor the bacteria, especially the common wild mustard.

If possible, cabbage should be set each year on ground which has not been planted to it for some time, or which has been in sod several seasons, or else cultivated to crops which are not affected by the rot. The one important thing for the gardener to observe if he would be a successful cabbage grower, is to take the utmost care to keep his field from becoming infected, and if once infected not to spread the malady over his whole farm.

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*Bull. 232, N. Y. Expt. Sta.

†Farmers' Bull. 63, U. S. Dept. Ag.

BACTERIAL BLIGHT OF THE IRISH POTATO, TOMATO, EGG PLANT AND TOBACCO.

Dr. Erwin F. Smith,* Bureau of Plant Industry, U. S. Department of Agriculture, has shown that a single species of bacteria, *Bacillus solanaccarum* (Smith), has the power of producing a blight or wilt in a number of plants of the potato family. Among the common ones attacked may be mentioned the Irish potato, tomato, pepper and egg plant. In 1903, Dr. F. L. Stevens† and the writer published an account of what appeared to be a bacterial wilt of tobacco in Granville County, North Carolina, to which the name Granville Tobacco Wilt was given. The very recent work of Dr. E. F. Smith‡ confirms this finding and further shows the cause of the disease to be none other than the organism which produces the potato blight. Several common weeds, such as the horse nettle, jimson weed and ground cherry, are also susceptible to the disease.

The blight manifests itself in the vines by a sudden wilting, either of a part or the whole. The stems usually wither, turn yellow and finally black. Young plants appear to contract the disease more readily than old ones. By cutting across the affected stem one can see the characteristic brown or black, woody tissue in which the bacteria are at work. A section across the sick vine just at the surface of the ground, or a little below, will usually show, in addition to the blackened ring, a considerable quantity of a slimy, viscid liquid oozing from the blackened parts, especially if squeezed between the fingers. This is particularly true if the soil is rather moist. Microscopic examination shows this liquid to be swarming with the bacteria, which cause the trouble. It frequently happens in the early stage of the disease that the blackening seen in the cross section of the stem will not appear as a continuous ring, but only as one or two spots. If the vine is slit lengthwise through one of these spots, a blackened streak will usually be found running the whole length of the stem and finally out into the branch or leaf which showed the wilt. The germs appear to live in the soil and gain entrance to the plant through the root or underground stem, and once within the tissue they clog up the water tubes and later on destroy the conducting vessels so that no water can be transported from the soil to the branches and leaves and, as a result, we get the characteristic wilting. The tubers from sick plants show a distinct ring of discolored tissue a short distance from the outside of the potato.

Fungicides are of no value in treating this bacterial disease

*Bull. 12, Div. Veg. Path., U. S. Dept. Ag.
†Bull. 188, N. C. Expt. Sta.
‡Bull. 141, Part II, Bur. Plant Industry, U. S. Dept. Ag.

since the germs are inside of the plant, as well as in the soil, and so far as our present knowledge goes, there is no practical method of sterilizing soil in the field. Prevention is the only remedy. Do not use diseased tubers for planting and avoil planting on potato-sick-land as well as on land which has had diseased tomatoes or egg plants.

This disease must not be confused with the fungus blights, known as early and late blight, which respond quite readily to spraying with Bordeaux mixture. In this case, the organisms which cause the blight grow on the outside of the vines and can be easily reached and destroyed by the spraying mixture.

The symptoms of the blight in the tomato and egg plant are much the same as those for the potato. The vines wilt as if suffering from too hot sun or lack of water. Decay of the stems and branches soon sets in, resulting in the destruction of the plant.

Here, too, spraying has been found useless, for the cause of the disease is deep seated within the tissue and beyond the reach of any germicide. Insects, undoubtedly, play some part in carrying the germs from plant to plant and thus spread the trouble, but the soil seems to be the principal medium of infection. What has been said in connection with the potato may be said about planting tomatoes and egg plants on land that has had diseased specimens of the potato family.

If the disease is not too general, it is possible to control its spread by removing the dead vines with the roots from the field and burning them. It is of utmost importance that the vines be destroyed and not thrown down carelessly to start the disease in a healthy part of the field. Remember that you are dealing with a contagious disease and it is your duty to keep it from spreading. One sick vine in your field this year may mean the loss of half your plants next year. Numerous cases have been reported where soil diseases have been carried from farm to farm, up and down the road by the infected mud that adheres to the wagon wheels. The greatest care should be exercised in plowing and cultivating not to drag sick vines over healthy soil, for by so doing the disease is spread, and what might have been a mild attack is aggravated to such a degree that a general epidemic results. Tools should be thoroughly cleaned before going from an infected field into one free from the disease and, as a further precaution, they should be disinfected by washing or dipping them into a 5 per cent. solution of either carbolic acid or copper sulphate, commonly known as blue stone. It is important that the gardener's shoes, as well as those of his horse, be free from clumps of infected soil before going into a new field.

There is a common practice among some farmers of hauling

the soil that has washed down a hillside back up onto the shallow places of the farm. If this is done, one should be very certain that the hillside from which this soil has washed is free from all plant diseases, for the writer is familiar with several instances where infection has been spread over healthy land in this way.

Where no remedy can be given, it is clear that our only hope of controlling a disease is by preventing its spread. By observing the foregoing suggestions, it is believed that the most serious plant disturbances can be prevented to a great extent, or at least controlled.

BACTERIOSIS OF BEANS.

Frequently the foliage, stems and pods of the common beans, as well as the Lima bean, are preyed upon by a bacterial disease, *Pseudomonas phaseoli* (Smith), known as Bacteriosis. The symptoms are such as to make it readily distinguishable from all other maladies to which the bean is heir.

There appear on the different parts of the plant, especially on the leaves, large, watery, brown patches or blisters that soon dry up and cause the tissue to become brittle and to curl, leaving the foliage ragged and good for nothing. The pods seem to furnish the best food supply for the microbes and it is here that we find the disease at its best. Small discolored spots appear at first, which spread very rapidly and produce large lesions with pink or reddish brown borders, and which have pale yellow or amber colored crusts over the affected areas. This crust is due to the accumulation of myriads of amber colored bacteria which have formed a layer over the broken down tissue. After a time the pod rots and the beans are worthless.

Warm, wet weather seems to favor the disease, for the germs grow best under these conditions, and the beans at this time produce succulent growths, which are more readily attacked. Rain and dew are doubtless agents in spreading the germs from one part of the plant to another by washing them from old lesions onto unaffected parts. Insects play an important part in disseminating the trouble, consequently any measures which tend to check these pests will aid in controlling bacteriosis. The distribution of the disease is further effected by dead vines and leaves carried on the wind; by the soil, and through the seed. New land which has never grown beans seems to be freer from the disease than old, and should always be used when available.

The seed used in planting should be selected by hand and all the lighter ones discarded, since experiments show that diseased seeds are less dense than sound ones. As yet no satisfactory method has been found which can be recommended for treating the seed to destroy the causal microbe which does not lower the viability of the seed.

Inasmuch as the germs of bacteriosis work on the outside of the plant, it is possible to reach them with a fungicide and spraying with Bordeaux mixture upon two and three-inch plants, followed by the same ten days later and again after blossoming. Dr. Halstead uses a Bordeaux mixture of the following strength: Copper sulphate, 6 pounds; lime, 4 pounds; water, 60 gallons.

Variety tests conducted by the New Jersey Experiment Station during the three years 1897-1899 with Green Flageolet, Currie's Rust-proof, Early Mohawk, Golden Wax, Extra Early Refugee and Saddleback Wax, showed the Green Flageolet the most susceptible, and the Early Refugee the least.

WILT OF THE CUCUMBER, CANTALOUPE AND SQUASH.

With the appearance of a rust resistant cantaloupe in 1905, the history of which has been published by Mr. P. K. Blinn,* one of the greatest terrors to cantaloupe growing disappeared.

There is, however, a bacterial wilt which is frequently met with on cucurbits and which has been especially severe in its ravages upon the Hubbard squash. It frequently happens that the cantaloupe and cucumber are also attacked, the greatest damage occurring early in the season when the vines are just beginning to run. This disease is easily told from all other ailments of the cucurbits in that it is characterized by a wilting of the vine, pure and simple, without any visible external causes, such as rust or leaf spot. The symptoms are the sudden wilting of the leaves and runners as from lack of water or too hot sun, the runner becoming prostrate on the ground. From two to three days usually elapse before the wilting of the whole vine is complete and it is sometimes longer. It may remain in this wilted condition for several days, after which the leaves begin to dry up and ultimately die. Usually, one runner will die at a time, beginning at the tip and working back toward the root. There is no discoloration or other injury to the leaves; they simply wilt, dry up and retain their green color for considerable time.

A microscopic examination of a cross section of a wilted runner, taken near the root, or from the root iself, will show the water tubes leading out into the wilted vine to be literally clogged with bacteria. Under such conditions, the plants can get no water from the soil and a natural wilting follows. A very simple field test, and at the same time a reasonably reliable one, is to cut off a piece of a wilted runner close to the root, cut it in two crosswise and gently squeeze the freshly cut ends between the fingers; a semi-viscid liquid will ooze out from the cut surfaces and if these be rubbed together

*Bull. 103, Colo. Expt. Sta.

gently and slowly separated, this sticky liquid will string out in fine threads an inch and a half or more in length. The juices in the healthy, normal stem do not possess this viscid nature to such a degree and this phenomenon may be taken as an indication of the bacterial wilt.

Growers seem to think the disease is worse during wet weather and just after a heavy rain, especially if the sun comes out very hot. If such is the case, it is probably due to the fact that these conditions favor the growth of the germs and bring about a more rapid distribution of the bacteria through the plant.

The microorganism which causes the disease, *Bacillus tracheiphilus* (Smith), lives in the soil, in the decaying leaves and vines of the different cucurbits and probably gains entrance into the host plant through the root or some injured spot on the runner. Plant on new land as far as possible and avoid the use of fields which have shown the infection. In all probability, wilt lives in the soil for five to ten years and perhaps longer. For this reason no squash or other member of that family, which will furnish food for the germs, should be grown on sick land during this time. While rotation with other crops is in no sense a cure for the diseased soil, it is to be strongly recommended over attempting to grow cantaloupes or squash year after year, in spite of the disease.

Careful observations have shown that when only a few vines are affected, the disease is often spread over the whole field by the cucumber beetle and squash bug, hence the necessity of destroying these insects. While no direct benefit is derived from spraying, so far as killing the germs of the wilt is concerned, good often follows such treatment, because of the destruction of insects which carry the disease from plant to plant. Since no specific remedy can be recommended and no wilt resistant varieties can be offered, preventative measures alone are left at our disposal. Where the infection is not too general and it is confined to a few hills, further spread can often be prevented by digging up the vines and *burning them.*

NOTE—It is earnestly desired that the farmers, gardeners and fruit growers of the State of Colorado will co-operate with the Experiment Station in furthering the study of bacterial plant diseases by reporting all diseases of this nature that may come under their notice, and also by sending in specimens of suspicious material for examination. Wherever possible, the whole plant should be sent, for usually root, stem and leaf are required for a satisfactory diagnosis. Address communications relative to suspected bacterial plant diseases to,

BACTERIOLOGIST,
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PRUNING MATURE FRUIT TREES

BY

O. B. WHIPPLE

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PRUNING MATURE TREES*

O. B. WHIPPLE

INTRODUCTION.

Many and varied are the excuses offered by the man who owns an unpruned orchard; he is ashamed of the neglected trees and tries to justify himself by advancing what he considers, or more likely what he tries to persuade himself, is a good reason. One holds that pruning is little short of sacrilege, contrary to the laws of nature; another tells of his fond recollections of childhood and what excellent fruits he picked from the old apple tree, pruned alone by nature; another says it does not pay, and in his particular case it does not, for the chances are that the orchard is neglected otherwise. The only excuse that has any semblance of justification is that of ignorance, and that does not excuse the man who makes no attempt. Nature's object is the production of seed with provision for its distribution, and she is satisfied when a cherry is produced with enough flesh to attract some fruit-loving bird that may, perchance, drop the seed far from the parent tree. Man grows the fruit for its fleshy parts, and tries to improve these parts, as much by placing the plant in a more favorable environment, as by plant breeding and selection. The man who has the fond recollections of childhood would no doubt find them only childish fancies, as did the man who returned to his childhood home and tried coasting, he would be disappointed. The man who cannot afford to prune, cannot afford to grow fruit, and the man who does not know how to prune must learn; the principles are not complicated.

PHYSIOLOGY OF PRUNING.

To be an intelligent pruner one must know something of plant physiology. He should know the effects produced by pruning at different seasons of the year, how to make a cut that will heal most readily, and the influence of pruning on the fruit bearing habit of the tree. It may be said that in Colorado the fruit grower prunes at his leisure, but luckily this conforms pretty closely to the proper season, when looked at from a physiological point of view. It is generally conceded that pruning during the dormant season incites wood growth, while pruning during the growing season promotes fruitfulness; and, since our trees tend to overbear, it is logical for us to prune largely during the dormant season.

Although it is said that pruning during the summer season may encourage the formation of fruit buds on tardy bearing varieties, it may have the opposite effect, unless done at the proper time,

*This bulletin is supplementary, to Bulletin No. 106, by Prof W. Paddock, which deals with the pruning and training of young trees.

and may cause late growth and unfruitfulness. To give the desired results one must summer-prune shortly before the season of growth ends; earlier pruning starts new growth, while late pruning gives no results. The benefit derived from summer pruning seems to depend upon the ability of the pruner to prune at a time to bring about early maturity. In an irrigated section where soil conditions are easily controlled, the same end may, no doubt, be more easily attained by proper manipulation of the irrigation water.

Both the season at which the wound is made and the character of the cut have an influence upon the healing process. The pruner should remember that all food material capable of healing a wound is taking a downward course through the inner bark and that, to heal well, a wound must be in a position to intercept the downward flow of sap from foliage higher up. When a limb is to be removed entirely, the cut should be at the union with, and parallel to the surface from which the limb arises. Where limbs are to be headed-back they should be cut to a side limb and not to a bare stub. Wounds naturally heal best when made at a season of the year when growth is most active, but, with the possible exception of wounds made in early winter and subjected to a long season of drying, the season at which the wound is made has no important bearing upon the healing process. The grower who has a small orchard that will permit of such a practice, should delay the pruning until as near the opening of the growing season as possible.

The influence of pruning upon the fruit-bearing habit of the tree has been briefly mentioned, but the following pages will show how a fruit-bearing habit may, to a certain extent, dictate a course in pruning. The fruits with which this discussion has to deal have two general types of fruit-bearing; from terminal fruit buds and from axillary fruit buds. The first type of fruit bud is well represented in the apple and pear, and the latter in the stone fruits. Trees which produce axillary fruit buds are naturally more prolific and require severe pruning as a means of thinning the fruit. In fact, a system of pruning under which the tree with axillary fruit buds would thrive, would cause the apple tree to overgrow to such an extent that it would be rendered almost barren. The point may be more fully illustrated by comparing the peach and the cherry. Although both develop axillary fruit buds they differ in their fruiting habits; the fruit buds of the cherry are seldom found on the stronger growing new wood, and severe pruning, as practiced on the peach, would throw much of the strength of the tree into the production of strong wood that would carry very few fruit buds. We have said that in the apple the type of fruit-bearing is from terminal buds, yet, many varieties develop axillary fruit buds. Varieties which develop axillary fruit buds and bear terminal fruit buds on young

spurs all tend to overbear, and require severe pruning. So to a certain extent one can decide for himself how much to prune by observing how the tree bears its fruit.

TREATMENT OF WOUNDS.

The argument in favor of dressing wounds is that it prevents decay and checks evaporation, both of which might interfere with the healing process. While in our arid climate the first is hardly applicable, the second should probably be doubly important. Yet, the matter of dressing wounds is not so important, but that work improperly done is worse than no treatment. A good lead paint is one of the most satisfactory dressings yet found. Rather a thick paint should be used, and careless daubing of the surrounding bark should be avoided. Grafting wax is a good dressing, but is rather expensive and difficult to apply. Other materials have been used, some successfully and some disastrously, and the grower is to be cautioned about experimenting; better stick to materials known to be safe and efficient. Growers often overdo the matter and waste time treating small wounds. Surely a wound less than one and one-half inches in diameter is not worth bothering with.

These suggestions apply to wounds made by the careless cultivator, as well as those made by the pruner. Unsightly wounds and permanent injury may often be avoided by proper treatment of trunk wounds. When the body of the tree is injured the ragged edges of the bark should be pared off to sound tissue and the whole injury covered with paint or grafting wax. If promptly done, this prevents drying out of the tissues, and new bark will readily form, except on parts where the outer wood cells are actually destroyed, and in time this will grow over. Wrapping the injury with cloth, or if it is near the ground, mounding earth up over it will often answer the same purpose.

PRUNING TOOLS.

Every pruner should be furnished with good tools; good tools encourage him to do good work. This does not necessarily mean that he must have every tool on the market, many of them are useless; it does mean, however, that the axe and a dull saw have no place in the catalogue of pruning tools. The pruner needs a good saw, a good pair of light shears, a pair of heavy shears, possibly a good heavy knife and, of course, a good ladder. Two common types of saws are found on the market. The common saw with teeth on both edges is a good, cheap one and will answer the purpose in many cases. The various makes of the swivel saws are much handier, however. The blade is stretched between swivels and can be turned to any angle with reference to the frame. It is well adapted to close work in the crotches of the tree. This type of

saw can generally be bought for three dollars. The blades are not so frail as they look and seldom break, if properly handled; they can be replaced at a cost of fifty cents. It is really the best type of pruning saw and should be more universally used.

A good type of hand shears is indispensable for light work. Various makes are on the market; buy the one that appeals to you. A pair of heavy shears is almost as essential; they take the place of the saw in many cases and will do the work in less time. They are used in heading in limbs where the saw can hardly be used; the peach pruner finds good use for them. They work well on limbs up to one and one-half inches in diameter. The only objection the writer has to this tool is that the pruner sometimes gets careless and leaves stubs. There is a type of heavy shears on the market that has two cutting edges instead of one, but it seems to do no better work. The pruner finds very little use for a knife in pruning mature trees and seldom carries a special pruning knife. Several types of the long-handled tree-pruners are on the market, but they are of little value in the orchard. The pruner should be close to his work, and with a good ladder and short-handled tools he will do better work.

SUGGESTIONS FOR PRUNING AS APPLIED TO SPECIFIC PLANTS

THE APPLE.

With the young orchard well grown, the pruner has probably solved the most difficult problem in the pruning of the apple orchard; the principles involved in the pruning of the old orchard are not complicated. Nearly all of our standard commercial varieties of apple tend to overbear in Colorado, and one of the first objects of the pruner should be to overcome this tendency; the more prolific the variety the heavier the pruning. To be an intelligent pruner one must also acquaint himself with the habits of growth of the different varieties, as well as habits of fruit bearing. Upright-growers will require pruning to spread them, and straggling-growers such heading in as will make them grow more upright. The head should be kept reasonably open and well supplied with fruiting wood throughout. The idea of the open head, however, can be overdone. (Fig. 1.) Limbs that interfere or are liable to form bad crotches should be removed and the main branches headed in as the tree indicates the need by overbearing or by weak growth. Moderate annual prunings are always to be preferred to heavy pruning at irregular intervals; these heavy prunings tend to upset a regular bearing habit and may bring on an "off-year." However, if it should become necessary to employ drastic measures in pruning the neglected orchard, do not be afraid to do it, but do not make the mistake of selecting an "off-year" in which to do the heavy pruning.

A discussion of the amount of pruning required by different varieties could almost as well be introduced as those on the pruning of different kinds of fruit trees. Yet, the growth of the tree, and necessarily the pruning, depends much upon soil conditions; and, while it might be possible, it would hardly be safe to lay down definite rules for the pruning of any particular variety. Both the Winesap and Missouri (Pippin) may be classed as prolific varieties that require sereve pruning. The Jonathan, at the age of eleven or twelve years, almost invariably begins to grow spindling in the top and requires frequent cutting back to keep the tree in a thrifty condition. Figure 3 shows a Jonathan tree well headed-in, with stocky growth, while Figure 4 is of a neglected tree of the same variety, of the same age. These willowy limbs bear small leaves and an abundance of apples that rarely come up to size, and the liability of such neglected trees breaking down under a load of fruit is well shown in Figure 2. Figure 3 shows how sprouts are largely avoided by cutting to side limbs. Varieties that bloom heavily but set very few fruits should be treated as varieties that overbear; prune them heavily during the dormant season. Varieties that refuse to develop fruit buds should not be pruned excessively, during the dormant season at least. Summer pruning is supposed to incite fruitfulness, but does not always give uniform and satisfactory results. Such varieties may be forced to fruit more easily by withholding water in midsummer, or better still, plant them on a light soil; poor bearers are nearly always strong growers, and very often a shy bearer on heavy soil is prolific on a gravelly hillside. The Yellow Newtown is a striking example of a variety of this type. The growth and fruiting habit of the tree, we will see determine largely what treatment it shall receive at the hand of the pruner. While pruning may not take the place of thinning entirely it may be employed as a means of correcting the faults of alternate bearing and of overbearing.

PRUNING THE APRICOT.

In the general growth and fruiting habit of the tree the apricot occupies a position between the cherry and the peach. The fruit buds are developed in the axils of leaves on both shortened spur-like twigs and the stronger growing new wood. These fruiting spurs of the apricot differ from those of the cherry in that they develop no true terminal buds. The apparent terminal of the new growth is a lateral bud and may be either a fruit bud or a branch bud. It is generally a branch bud, but it is not uncommon to find weak spurs bearing only fruit buds, and such spurs with no branch bud to continue their growth must perish at the close of the fruiting season.

The general plan of pruning the apricot will resemble that fol-

lowed in pruning the peach, although, as a rule, it should be hardly as severe. The young tree is a strong grower and must be put through about the same course of training as the young peach. This strengthens or stiffens the frame work and develops a broad, low-headed tree. Normally the tree does not grow as much new wood as the peach, and it is often possible to do the majority of pruning by simply heading in the strong growth. The pruning should be sufficient to keep the fruiting wood growing thriftily and the tree well within bounds. While to a certain extent pruning reduces the labor of hand thinning, it will not take its place entirely. If properly thinned, the apricot will stand much neglect as regards pruning, but proper pruning is a matter of economy. As the tree grows older it will need more severe pruning to force new fruiting wood in the center. The absence of fruiting wood in the center of the carelessly pruned apricot tree is even more pronounced than in the neglected peach tree. The top should be well spread and the fruiting area of the head maintained near the ground.

While the season for pruning the apricot in Colorado generally extends through February and March, summer pruning is quite extensively practiced on the Pacific coast, where the trees are headed in as soon as the crop is harvested. This starts the smaller laterals into stronger growth and they develop an abundance of fruit buds. Limited observations of the same system employed in our climate suggest that it may not be without merit here. While this late growth is inclined to be immature and may suffer from severe winter freezing, it is more desirable from the standpoint of late blooming. Fruit buds on this immature wood open from four to five days later than those on mature wood. This may frequently be an advantage in localities where late spring frosts are not uncommon. The advisability of such a practice has not been fully demonstrated and is given only as a suggestion.

THE CHERRY.

The man who objects to pruning, vowing homage to nature, should grow cherries, for there is no fruit tree of which it may be said that nature is a more efficient pruner. In fact, it is a common impression among fruit growers that the mature cherry tree needs no pruning. This condition of affairs, however, is more largely due to indifference on the part of the markets than to an inability to get results from pruning. When competition becomes more keen, fancy grades of cherries will gain in popularity and, as in the growing of other fancy fruits, pruning will be found expedient.

With the cherry the fruit is borne on one-year-old wood and mostly on short growths, or spurs. An examination of the spurs will show that they differ from those of the apple in that they carry

Fig. 1.—An exaggerated type of open head; a waste of fruiting space in a Colorado apple tree.

Fig. 2—A tree allowed to grow at will. Ruined by a heavy crop of fruit. It was not overloaded for it matured its crop, but the fruit was all near the tops of the long arms.

Fig. 3—Jonathan tree well headed-in and stocky. Such a system of pruning is necessary with the mature Jonathan.

Fig. 4—A neglected Jonathan. The leaders are long and willowy and the tips are loaded with fruit spurs. The top of these leaders develop small leaves and set a large crop of fruit that rarely comes up to size. All these leaders should be cut back to strong laterals. A candidate for the same fate as Fig. 2.

Fig. 5.—A five-year-old Elberta peach tree. Almost perfect. This tree should not be allowed to grow much higher.

Fig. 6.—A four-year-old Elberta. Good form; has made a good growth with fruiting wood near the bottom as well as in the top.

Fig. 7.—The same as Fig. 6 after pruning. Plenty of fruiting wood still left, and a good framework for a productive tree. In about one more season it will have reached the limit or height. It will broaden out a little yet if it is properly pruned in the top.

Fig. 8.—A seven-year-old peach tree getting too high. Notice how the fruiting wood is being smothered out below. About two more years of such pruning and it will be like the tree shown in Fig. 11. Severe pruning in the top will yet save such a tree without cutting down the yield in any one season. This tree has been spoiled largely because the pruner did not have the room to properly spread it.

Fig. 9.—Type of tree similar to that of Fig. 8, showing about how such a tree should be pruned. Could have been cut back a little more severely in the top to force more new wood below.

Fig. 10.—Eight year old peach tree that has been well pruned and trained. Notice how well the fruiting wood is distributed throughout the head. See how nearly it conforms to a right angle. An ideal shaped tree and the heavy pruning in the top indicates that the pruner does not intend to let it grow away from him. This tree is good for seven more years at least.

Fig. 11.—A tree of the same age as that shown in Fig. 10. The pruner has tried to increase the bearing surface by increasing the height of the tree, and notice the result. A tall, leggy tree with no fruiting wood below. This tree would be a good subject for a system of pruning similar to that shown in Fig. 12.

Fig. 12.—A peach tree severely cut back for the purpose of forming a new top. Some of these stubs will die back but the tree will form a good, new top. It would have hardly been safe to cut to stubs of this size had it not been for the smaller wood below.

Fig. 13.—A new top, two years old, on an eleven-year-old peach tree. Such a new top is well worth the loss of one crop of fruit.

Fig. 14.—A pear tree improperly headed-in. It is only reasonable to suppose that leaving large stubs with numerous fruit spurs bearing branch buds would result in a large number of sprouts. Heading-in will, of course, always start some sprouts, but their number may be greatly lessened by cutting back the leader to side branches.

Fig. 15.—Is the same tree as that shown in Fig. 14 one year later. It tells the whole story.

both terminal and axillary buds, the terminal with few exceptions being a branch bud and those developed in the axils of the leaves mostly fruit buds. Fruit buds are also found as axillary buds near the base of the stronger growing new wood. The cherry, then, has a fruiting habit which would indicate that the tree will stand only moderate pruning. Trees overpruned produce an excess of strong, new wood with few fruit buds. In neglected trees the spurs become weak and spindling from constant bearing; the flowers are borne singly in the buds, when they should be in pairs or triplets, and the tree produces a large number of medium-sized fruits.

The manner of pruning will depend somewhat on the variety, but the general plan should be to keep the fruiting area of the tree as near the ground as possible; to shade the trunk, to prevent sun-scald, and to encourage the growth of fruiting wood throughout the entire top. The sweet and semi-sweet varieties are upright growers and will need some heading in to keep them within bounds. The rapid growth forced by pruning must be checked by careful watering. Unless this precaution is heeded immature growth will result and, young trees especially, may be killed outright during severe winters. Like the Anjou pear, some of the cherries produce an excess of weak fruit buds that fail to set fruit. When this is found to be the case it is a good sign that the tree is not being pruned as severely as it should be. Heavy pruning during the dormant season will often correct the fault. On the contrary, lack of bloom is generally due to excessive pruning or overwatering. Occasionally we find a variety where this fault is characteristic, but it may generally be overcome by proper handling.

PRUNING THE PEACH.

There is probably no fruit tree that gives the careful, observing pruner as much pleasure in pruning as does the peach. Results soon indicate whether the pruning is right or wrong, for no fruit tree will suffer more from neglect, and none respond more promptly to careful treatment. This prompt response, so plainly indicated, lends not a little inspiration toward the proper training and care of the peach orchard, and it is safe to say that, largely on this account, no fruit tree is better pruned than is the peach in our recognized peach sections. The practice is simple, and lack of courage is more often responsible for failure rather than complicated principles. As mentioned before, the peach develops its fruit buds in the axils of the leaves, and the fruit is borne on one-year-old wood; a system of fruit bearing that makes severe pruning a prerequisite to successful peach growing.

In pruning the peach the object of the pruner should be to cut out enough wood to force good, strong growth each year; to re-

move superfluous fruiting wood, and to give the tree the desired shape. The mature peach tree should make an annual growth of at least eighteen inches. With such new growth much of the new wood will have to be removed entirely while that remaining may be cut back to remove a part of the fruit buds it carries. While some object to shortening-in the fruiting wood, contending that it injures the fruit, the years of experience of our most careful growers recommend rather than condemn such a system of thinning. While it does not take the place of hand-thinning entirely, it does save a great deal of tedious hand work. It is hard to say just how much of the new wood is to be removed or how much the remainder should be shortened in. Probably four-fifths is removed entirely, the amount removed from that remaining depending more upon the location of the fruit buds. With the older tree it may be half or even more, while in the case of the young tree it may be necessary to leave the laterals unpruned, on account of the fruit buds being nearer the tips. Figure 6 shows a four-year-old Elberta that has made a very satisfactory growth. Figure 7 shows the same tree well pruned. From now on this tree must be carefully watched to keep it within bounds. As the framework stiffens the tree may be spread a little more, but it should not be allowed to go much higher. It is a common practice to do the heavier pruning earlier in the spring, leaving the clipping back and thinning of the new wood until later, some waiting until all danger of frost is past. The pruner should constantly keep before him an ideal form for the peach tree, the well grown young orchard, at the mercy of a careless pruner, may become ungainly and unproductive at the age of ten years. Effort should be made to keep the fruit as near the ground as possible; most of the fruit on a five-year-old tree should be reached from the ground, and in no peach orchard should the picker need a ladder longer than six feet. (See Fig. 5.) The depth of the fruiting area of the peach tree will seldom exceed six or seven feet, and an attempt to increase this depth only results in a smothering out of the wood below. Figure 8 shows a seven-year-old tree that is really getting too high.. Note the scarcity of fruiting wood in the lower part of the tree. This tree may be forced to develop new wood below if the top is well cut back. Figure 9 shows about how such a type of tree should be pruned. This tree could have still been pruned a little heavier in the top. A better plan is to increase the productiveness of the tree by increasing its spread rather than its height. The ideal peach tree is one in which the top just comes within a right angle or, in other words, the spread should be almost double the height. Figure 10 illustrates the point very well. Notice how the head is well filled with fruiting wood, and compare with Figure 11, a tree of the

same age. With such a system of training the first tree will be productive at the age of fifteen years, while the latter, now ten years old, must be rejuvenated by severe heading-in or be discarded as unprofitable. There is no fault to which the old peach tree more often falls heir than that of the absence of fruiting wood in its lower parts. Such wood below can only be maintained by vigorous pruning in the top. The center should also be well filled with fruiting wood, as space may be unnecessarily wasted by training the top too open; the open center is not a necessity in our arid sections where we enjoy an abundance of sunshine. The fruiting wood in the center of the tree will hardly appear as strong as that nearer the tips, but, nevertheless, some of our best fruit comes from short and apparently weak spurs along the larger limbs. Some have tried summer pruning (thinning out the new wood in the center of the tree), hoping to strengthen the wood remaining, but it has not given satisfactory results; too often it starts new growth that is immature and unfruitful.

It is seldom that we read a paper upon the subject of pruning the peach orchard without we see some reference to the treatment of winter-injured trees. With the exception of young trees grown too late, or orchards in higher altitudes or northern latitudes, such injury it not often experienced in Colorado. It is well for the grower to remember, however ,that the winter-injured peach tree makes the best recovery when it has received a moderately severe pruning. Another subject more worthy of mention is that of the rejuvenation of the old peach orchard. The occasional loss of a peach crop by late frosts offers an excellent opportunity to grow a new top on the old peach tree. Figure 12 shows a peach tree headed-in to secure a new top, while Figure 13 shows a tree eleven years old, two years after such a pruning. The cutting back should be done as soon as possible after the loss of the crop can be ascertained; severe pruning as late as the first of June forces rank new growth that develops very few fruit buds. Rather large limbs may be cut if the bottom of the tree has some smaller growth, but cutting to bare stubs over two or three inches in diameter is hardly advisable.

THE PEAR.

The mature pear tree is not one that requires a great deal of pruning, nor does it allow lack of pruning to interfere seriously with its proper behavior, so far as fruit bearing is concerned. However, when the market demands that the fancy pear be from 2¼ to 3¼ inches in diameter, the owner of the old pear orchard is often reminded that the trees need pruning. In general, the manner of fruit bearing of the pear is practically identical with that of the apple. The spurs are a little shorter and give the tree rather a

more barren appearance; and, although some varieties develop axillary fruit buds quite freely, the majority of the fruit buds are terminal on these short spurs. The different varieties vary somewhat in their fruiting habits, and a study of this character will, to a certain extent, indicate how much pruning each will require.

Apparently the grower accepts the upright-growing habit of the pear as the inevitable, with hardly so much as an effort to train it otherwise. With proper training there is no reason why the pear tree may not be grown with a moderately broad and low head. Pears that grow in the tops of high trees are too often scarred, if not whipped off by wind, before they are mature and, besides, it is too expensive to pick them. The forming of the tree belongs more to the province of pruning the young tree; but a little judicious heading-in practiced on the old tree, taking care to cut to outside buds or branches, will improve on an undesirable form. Too often the tree is allowed to grow at will until it is out of reach, and then, in a fit of desperation, the grower resorts to a system of heading-in shown in Figure 14. This system may be all right for the lawn hedge, but it is not well adapted to the pear, as is shown by Figure 15, the same tree one year later. By the time the pruner gets through with this tree he will have decided that it is poor policy to head-in pear trees. Had the pear tree been properly headed-in from the beginning, the result would have been different. It is only reasonable to suppose that leaving stubs of large limbs which bear numerous fruit spurs will result in rank growth from these spurs, especially during an "off-year" when the spurs carry a large proportion of branch buds. When it becomes necessary to head-in the large pear trees, always cut to side limbs and do not make the mistake of choosing an "off-year" to do this severe pruning; a heavy crop tends to check rampant growth encouraged by rigorous pruning.

While some growers really believe that the pear tree will not stand pruning, we know of no variety to which moderate pruning is detrimental. On the other hand, there are varieties which require severe pruning. In spite of the fact that the Anjou pear is a favorite on the market, many growers will not consider the planting of this variety. Yet a few of its more forbearing admirers have demonstrated that its one bad fault (tardy bearing) may be overcome by proper pruning. The young tree blooms freely and apparently sets very well, but before the fruits reach any size the crop thins itself to almost nothing; even the old tree carries a very small proportion of its bloom to maturity. Heavy pruning during the dormant season will stop this shedding and insure a good crop of fruit. The practice of the most successful growers is to cut the tree back each year and remove some of the new wood that may have been forced by the last pruning. When once the tree begins to bear

good crops, there is less trouble about its shedding. Some other varieties are more tardy about blooming, and heavy pruning during the dormant season would only augment this objectionable character. Such varieties often respond to June pruning; and, if they do not, girdling in June will often prove beneficial. In girdling, a strip of bark one-quarter of an inch in width and extending entirely around the trunk may be removed; but perhaps a safer plan is to remove vertical strips of bark one and one-half inches in width, leaving other strips of about the same width intact. If the wood is uninjured these wounds soon heal and do not permanently injure the tree.

It is difficult to say just how much the pear should be pruned; the grower will have to decide that for himself. The main object of pruning the mature tree should be to thin the fruit and thus improve the quality, as well as to encourage more regular bearing. However, the grower must not feel that pruning will take the place of thinning entirely; to get the best results the two must go together.

The subject of pruning the pear could hardly be considered complete without some reference to the control of pear blight. While it is true that when once the pear tree is inoculated with blight, we must lay aside many of our ideas about pruning and cut to remove the affected parts, it is also true that, in a way, the tree may be trained to reduce to a minimum the loss from attacks of this disease. After the tree begins to bear, heavy pruning which may induce rampant growth should be avoided, if possible, as it is generally conceded that blight is more destructive to trees making rank growth. The majority of inoculations take place through the blossoms, and one of the most serious types of injury is that occasioned by the entrance of blight into larger limbs through short spurs. Through these short spurs the germs gain entrance to the larger limbs and often girdle them before discoloration indicates their presence. It is the nature of the pear tree to develop these short spurs in abundance, and it will be necessary to remove them from the base of the larger limbs. Strong new wood may be allowed to take their places, which may later be developed into fruiting branches. Then should blight enter these blossoms, they are far enough removed from the main limbs that the disease may be detected and intercepted before it reaches them.

PRUNING THE PLUM.

Under this head is grouped a large number of species and varieties of fruit differing widely in their habits of growth and of fruit bearing. Were it not for the fact that common practice seems to discourage the pruning of many varieties to any considerable extent, this would be a difficult subject to handle; no well defined

system of pruning would suit all. In their habits of fruit bearing the majority of the plums resemble the apricot very much. Still many of them, like the cherry, show more of an inclination to bear only branch buds on the thriftier new wood. Like the apricot, the plums, with possibly a few exceptions, develop no true terminal buds. Except on weak spurs, the last axillary bud is generally a branch bud which continues the growth of the branch or spur the following season. The fruit buds are developed in the axils of the leaves on both spurs and the ranker growing new wood, the different varieties showing considerable variation in this respect.

The body of the plum tree is subject to injury from sun-scald, and it goes without saying that the tree should be headed low. The young trees of most varieties will need cutting back, and the tops thinning out, to develop them into desirable shaped trees. Some varieties will require pruning to spread them, and others of a more straggling habit, will need cutting back to inside buds or branches to make them grow more upright. As mentioned before, the bearing plum tree, according to local custom, receives at most only moderate pruning. As a rule, the Domestica plums, locally represented by the various prunes, are pruned very little after they reach the bearing age. There are certain varieties which tend to overbear, however, and a certain amount of thinning out of the fruiting wood would greatly facilitate hand-thinning, promote more regular bearing, and improve the quality of the fruit. The pruning of the native plums is left largely to nature, although there is no reason why moderate pruning might not improve the quality of the fruit and lessen the difficulty of picking. There is little doubt but that such varieties as the Burbank, Abundance, Satsuma, Red June, and others of the Japanese group, respond satsfactorily to rather severe pruning. In fact, they are more like the apricot in their fruiting habit and thrive under the same system of pruning. When neglected they tend to overbear alternate years. They should receive an annual heading-in and thinning out to force strong new growth, which makes very desirable fruiting wood. While pruning as a means of thinning the fruit is not without merit in the case of the plums, it does not seem to give results comparable with those obtained in pruning the peach. The grower of fancy plums must supplement moderate pruning with hand-thinning.

PRUNING THE QUINCE.

While the importance of the quince industry in Colorado might not warrant the insertion of this paragraph, the almost criminal neglect from which the quince tree suffers as regards pruning would move one to writing a book. Among the fruit trees herein considered, the quince has a fruit bearing habit peculiar to itself. With the advance of spring the dormant buds on the one-year-old wood push out leafy shoots from three to four inches in length and these are terminated by a single flower. While both axillary and terminal buds produce these flower-bearing shoots, the stronger flowers come from the axillary buds on the last half of the annual growth; terminal buds more frequently give rise to branches or, at most, weak flower-bearing shoots. Considering its fruiting habit then, the quince should receive about the same pruning as the peach. While with some varieties the plant assumes a tree-form quite readily, others are, at their best, only a bush. A course of severe pruning for the young tree, however, will aid the grower in securing a desirable shaped tree. When the tree has reached a bearing age it should be pruned annually by thinning out the new wood and clipping that remaining back to about two-thirds of its length. With proper pruning, the quince should produce annual growths from twelve to twenty-four inches in length. Too rank a growth is not

desirable on account of the stronger fruit buds being nearer the tips, and in cutting back such rank growth the pruning must not be too severe. The plant should be made to assume as near a tree-form as possible, and then. in addition, it should be pruned with the idea of growing a goodly supply of new wood each season.

THINNING FRUIT.

In fancy fruit-growing, the necessity for thinning will become more and more apparent as the acreage devoted to orchards increases and competition becomes more keen. While the wisdom of thinning peaches is no longer doubted, the growers are not so willing to take up systematic work in thinning apples and pears. But the time is coming when the fruit-grower will be forced to conclude that it no longer pays to grow poor fruit. Even now, the years that the grower makes a profit in shipping choice fruit, are the exception rather than the rule. There are but few localities where choice fruit cannot be grown, and wherever shipped, such fruit must generally compete with the home-grown product. On the other hand, localities where strictly fancy fruit can be grown are limited, and competition in this class is more impartial. The competition is between localities which are probably equally distant from the market, and the one producing the best fruit is the successful competitor.

To a certain extent, pruning is a method of thinning, but it will not take the place of hand-thinning entirely. The production of a fancier grade of fruit is not the only benefit derived from thinning; it encourages more regular bearing; lessen the loss from the breakng of limbs and gives the grower a chance to destroy insect infected fruit and thus check the spread of insects early in the season. The tree that has been properly thinned should produce a good crop of fruit buds each year, and if it has been properly trained and thinned it will never need a prop. While many have observed that apple and pear trees are inclined to bear alternate years, probably few understand the cause. Fruit spurs with terminal fruit buds, as those of the apple and the pear, generally bear only alternate years, and if the spurs are all full of fruit one year, the next must be an "off-year," as we say. Not only do the spurs fail to bear annually, but if the tree is overloaded, spurs that produce bloom, even though they fail to set fruit, may not be sufficiently nourished to produce fruit buds for the following season. If the tree bears only a moderate crop of fruit, spurs that produce bloom but no fruit, often develop fruit buds the same season. Where the tree is bearing a light load, spurs may mature fruit and develop fruit buds the same season. Varieties differ and, while some are regular bearers under almost any treatment, others show a stubborn inclination to bear alternate years. After the old tree has fallen into the habit of bearing alternate years it is no doubt harder to get it back to a regular bearing habit. "Off-years" are not uncommon with some of the fruit trees bearing from axillary fruit buds, but it is not so pronounced as with the apple and pear.

Thinning the Apple.—Fixed rules to be followed in thinning are hard to give. Much depends upon the general thrift of the trees, and, as in pruning, the grower will have to learn much by experience. If we thin to encourage annual bearing, it will be seen that all the fruit must be removed from some of the spurs and, at the same time, the number of fruits remaining must be reduced to such an extent that the tree is not overburdened. Some thin to leave the fruits so far apart, but a rule fixing a certain space between apples will not hold good in all cases. If we were always sure the tree had been properly pruned, we might be able to give a satisfactory rule to be followed, leaving the fruits so many inches apart. A plan the writer has tried and found very satisfactory is to so thin as to have a certain number of boxes of fruit on the tree. Suppose you decide that the trees should produce ten boxes of fancy fruit each. A fairly uniform grade of apples ranging from two and one-half to three inches in diameter will pack about 150 to the box, and by thinning two or three trees and leaving the 1,500 apples, actually counting them or estimating them as closely as possible, one

learns what a tree properly thinned should look like. With these trees as a model it is surprising how close one can come to leaving just the right number. I think it is possible, by careful work, to come within a box of the ideal. But knowing how much the tree should produce is where the experience counts. Not many varieties of apples will require much thinning before they are ten years old, and at this age the average tree should produce about eight boxes of fancy fruit; some will produce more and some less. After the tenth year a gain of a box per year would be a conservative estimate. Of course, the yield will vary under different conditions; and, while this is not a rule that can be implictly followed, it is surely more accurate than thinning to a certain distance. The thinner first removes defective or wormy specimens, and he should be supplied with a bag to carry the wormy ones from the orchard to be destroyed; then those from the tips of the limbs may as well be removed, for they seldom make fancy fruit; and, if possible to do it and leave the required amount, thin to one fruit on the spur. June and early July is the proper season for thinning apples and pears. Experiments have shown that it pays to thin apples. The fruit is improved in both size and color; the trees bear more regularly, and trees that may break under heavy loads are saved. Some say it is expensive to thin; but, if one stops to think, it really costs no more to pick fruit in June than it does in October. A man can thin from ten to fifteen twelve-year-old trees per day, and the actual cost of thinning should not add to exceed two cents per box to the cost of production. It is true that the results the first season are often disappointing, for an unthinned tree may produce sixteen boxes of fruit that will grade 50 per cent. fancy, while the thinned tree of the same age only produces ten boxes that will grade 95 per cent. fancy. It hardly seems profitable. but the next year will tell, and it is safe to say that two years running the thinned tree will produce as much fancy as the unthinned tree will produce of both fancy and choice.

Thinning Pears.—Methods of thinning pears differ little from methods of thinning apples; the principles are the same. As a rule, the pear tree will produce about as many boxes of pears as will the apple tree of the same age produce boxes of apples. The fruit is generally picked on the installment plan, and it is possible to mature a large crop of fancy fruit; and fruit that is small may be left until it reaches the decided size. Pears running from 135 to 150 to the box are considered ideal size, and pears for such a pack must measure from two and one-fourth to two and three-fourths inches in diameter. Pears larger than three inches are really not as desirable for the fancy fruit trade as those of smaller size. The fruit stands like a pear that can be sold at a profit, two for five cents, and there is no profit to be made in selling the larger ones for that price, and they are not large enough to sell for five cents each.

Thinning Peaches.—In growing peaches much of the thinning is done with the pruning shears during the pruning season, but additional hand-thinning is absolutely necessary. A good grade of peaches should run less than 90 to the box, and we may say it seldom pays to ship smaller fruit. A size that will pack less than 80 to the box is desirable. The young peach orchard that has been properly pruned will do well to average a box of fruit to the tree during its fourth season's growth, and the yield should increase at the rate of about two boxes per tree per year. Unless the trees have been exceptionally well pruned and cared for, they will rarely more than hold their own after the eleventh or twelfth year. The one object of thinning, as practiced with the stone fruits, is to produce better fruit. The thinning should be done before the foliage gets too heavy and before the pits begin to harden. By carefully thinning a few trees and estimating the number of fruits left, one can soon form an ideal to work by. The pruning shears may be used as a help in thinning, and fruiting wood not necessarily needed may be removed entirely.

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BY

B. O. LONGYEAR

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Strawberry Growing In Colorado.

BY

By B. O. Longyear.

One of the earliest horticultural crops to be cultivated in Colorado was the strawberry. It is probable that plants were first brought into this state from DesMoines, Iowa, by Mr. J. B. Wolf in 1863 and planted on river bottom land west of Denver. Altho this plot was destroyed by flood the following spring Mr. L. K. Perrin, of Denver, who had secured some of these plants, sold in 1865 the first Colorado grown strawberries for $3.50 a quart. This early demonstration of strawberry raising in Colorado has been followed in later years by the development of the business in certain parts of the state into an important commercial industry.

This bulletin presents the methods practiced by many of the most successful strawberry growers in localities where the industry is carried on on a commercial scale.

Soils. While the strawberry can be successfully grown on soils of widely varying character it does best on a sandy or fine gravelly loam. Such soils are more easily worked than those of a heavy, clayey nature and they produce earlier crops of better quality than the latter. Heavy soils, with good natural under-drainage, can be made to yield heavy crops especially when lightened with manure thoroughly incorporated with the soil or by plowing under late growth of alfalfa. Where the soil is not well drained naturally, tile drainage may often be used to remove surface water from the land. For altho the strawberry is a plant that requires a plentiful supply of moisture at the roots it is rapidly injured by a wet soggy condition of the soil.

Location. The land selected for strawberry growing should be level enough so that an even watering of the soil may be secured without danger of washing. Where the land is at all uneven, high places must be lowered and depressions filled, otherwise the soil will be too wet in some places while others go dry. If none but sloping land is available the rows may be run in such manner as to avoid a strong fall by following the contour of the slope.

Preparation of Land. The best growers lay much stress on careful preparation of the land. Fall plowing followed by a second plowing in spring is often practiced. This is especially desirable if the soil is inclined to become lumpy. Sandy loams are capable of good preparation if deeply plowed in late winter or early spring, followed by thorough harrowing. A leveler made of plank is employed to reduce lumps and give an even surface.

In case strawberries are to follow alfalfa sod, fall plowing and

harrowing are practiced and at this time the alfalfa roots are removed as the harrow loosens them. A second plowing in spring followed by the harrow and leveler until the soil is free from lumps completes the preparation of the land.

Fertilizers. Well rotted barnyard manure is the fertilizer commonly used for strawberries in this state. This is plowed under at the rate of 10-20 loads per acre. Fresh manure is somewhat objectionable on account of the weed seeds which it is liable to contain and also because it cannot be readily incorporated with the soil. Where composted manure is not available fresh manure is often used at the same rate.

Hen manure is considered the most valuable domestic fertilizer and where available it is usually applied in the fall or early spring as a top dressing to the rows. Being one of the strongest of manures it must be spread thinly to avoid injury to the plants.

Of the commercial fertilizers, bone meal is believed to be the most satisfactory as its effects continue for two or three years. Nitrate of soda is sometimes used during the blooming period with good results. On account of the readily soluable character of this fertilizer, two light applications, about two weeks apart, are better than a single heavy one. This fertilizer may be applied at the rate of 100 to 200 lbs. per acre.

PLANTING

Time. Spring planting is followed in this state almost without exception. Late summer and fall in this climate are usually characterized by hot days and cold nights and such conditions are unfavorable to starting young plants into vigorous growth. In case of small garden plots it is possible however to set plants in late summer and secure a light crop the following spring, especially in cases where plants can be obtained near by and moved with a small mass of soil around the roots. Potted plants can be obtained from the principal seedsmen for fall setting with the assurance of a fair crop the next spring.

The character of the season will usually determine largely the best time to set plants. In most cases this can be done in April which is the favorite month. Some growers say as early as possible so as to secure a strong growth during the first season.

Plants. Plants for a new plat are obtained either from some old bed near at hand or from the nurserymen. In the former case they are usually dug with a spading fork, often on the day before planting. The plants are placed in wet sacks as fast as dug and kept from drying out by an occasional sprinkling with water.

Plants received from the nursery may sometimes be kept for two or three days if the land is not ready for them and if they are received in good condition. They should be stored in a cool moist place, such as a light cellar, and occasionally sprinkled. Some growers prefer to buy plants from Eastern nurseries where they can be obtained earlier in the season than those from the home fields, and in this way get them well established before hot weather comes on.

The plants selected for planting are those having yellow roots, those with black roots being discarded as old or diseased. Careful growers also prefer plants that are nearest the old ones as the strongest plants are usually the first ones that set on the runners while those at the tips are weak.

Setting the Plants. Previous to planting narrow furrows are run with a shovel tooth cultivator, or similar implement, and the plants are set along one edge of the furrow. Two men work together; one opens the soil with a spade, the roots of a plant are placed in the hole behind the spade and spread apart with the fingers of the hand which holds the plant, the spade is then withdrawn and the soil is pressed firmly against the roots with the foot. The plants when set should have the crowns level with the surface of the soil. A stream of water is allowed to follow in the furrow close behind the planters and in this way the soil is settled and the plants watered at the same time. The distance between rows and plants in the row is varied somewhat according to conditions of land and the variety of strawberry planted.

System of Planting. Two systems, the hedge row or hill system and the matted row, are followed. In the former the rows are set 2½---3 feet apart with the plants twelve to fifteen inches apart in the row. All runners are kept off and strong individual plants are formed. This system is but little practiced here as it is adapted only to small areas on account of the greater amount of labor involved. The matted row is practically the universal system practiced in commercial strawberry growing in this state. It is claimed by some that it is the best system adapted to our climate as the fruit is better shaded from the hot sun while ripening. The usual distance between rows is 3 to 4 feet, the more nearly level the land the farther apart. For many varieties the plants are set 12---18 inches apart in the row, while such as the Senator Dunlap and other strong spreading sorts are set 18---24 inches apart.

Cultivation and Irrigation. The first irrigation is given at planting time and thereafter as often as needed to keep the young plants in a vigorous growing condition. Cultivation is given as soon after irrigation as the land will admit without danger of puddling the soil. Irrigation is not usually necessary oftener than every ten days to two weeks and the best growers aim to keep the plat absolutely free from weeds, especially during the first year. This necessitates hand hoeing together with the work of the cultivator. Of the latter implement one having twelve to fourteen spike or narrow shovel teeth and capable of being narrowed down readily is preferred by most growers. As the season advances the cultivator is gradually narrowed thus allowing the runners to root along the sides of the rows. In most cases the matted rows will be fifteen to eighteen inches wide at the end of the season with a correspondingly narrow clear space between them. Cultivation and irrigation are as a rule discontinued by September first to fifteenth depending somewhat on how late weeds continue to appear.

Winter irrigation is impossible in many districts because water is unobtainable at that season. In districts where water is available

however, two or three winter irrigations are considered very desirable and some growers prefer this to winter mulching.

Mulching. Considerable difference of opinion exists regarding the benefits of winter mulching. The majority of growers consider it desirable especially where winter irrigation is not possible. For this purpose straw, manure, marsh hay, or similar material is made use of. Many growers prefer a light mulch of fine rotted manure placed on the row as it does not require removal in spring. In many localities it is difficult to make any mulch stay on the plants on account of strong winter winds. Brush, poles, or similar material, when it can be had, is sometimes used to hold the mulch in place.

Cultivation is resumed the second year by some growers as soon as growth begins, after first removing the mulch, if any has been used, and is continued until the fruit sets. Others prefer to leave the mulch between the rows and pull the weeds by hand as they appear above the beds without giving further cultivation until after fruiting. In most cases, however, the mulch is removed as it would interfere with irrigation and shallow furrows are run between the rows for this purpose.

During the fruiting season irrigation is given frequently enough to keep the plants well supplied with moisture. Drying of the soil at this time not only reduces the size of the fruit but shortens the period of bearing as well. It is found that the rows should not be over eighteen rods long between laterals. Greater length than this necessitates keeping the water too long a time in the upper end of the rows in order that it may reach the farther end. The desirability of having the land as even as possible is apparent at this period for the plants in depressions are then flooded after which the fruit scalds under the hot sunshine. Irrigations during the picking season are given as soon as possible after the pickers have been over the field in order to allow as much time as possible for the soil to dry off before another picking is ready.

PICKING AND PACKING.

The berries intended for the markets are picked when somewhat under-ripe especially when intended for long shipment. The exact degree of ripeness can be gained only by experience and may vary somewhat with different varieties. A short piece of stem left attached to each berry adds greatly to the keeping quality of the fruit. The most successful growers aim to secure good pickers for the entire season. Each picker carries a tray holding six boxes into which the berries are picked directly. When the fruit is to be graded it is desirable to have this done when picking and thus avoid a second handling.

Facing the boxes consists of turning the stems of the upper layer of berries downward in each box. This adds to the attractive appearance of the fruit and is preferred by many dealers. Several methods of tallying the pickers are employed. The simplest is that in which a book or slate is used to record, opposite the name of each picker, the number of boxes picked. Some use tickets stamped or printed with the growers name and numbered 1, 2, 6, 12, 24 qt., each different number being on

cardboard of a different color. These tickets are given to the pickers according to the number of quarts picked and are later redeemed by the grower.

The universal package in use in this state is the Leslie box and crate, each crate holding twenty-four quart boxes. These are usually purchased flat by the grower and made up during the winter or when time permits. Some kind of shelter is necessary under which the packing can be done. This is usually located at one side or end of the field and commonly consists of a rough board shed, a tent or other portable structure.

MARKETING

A great deal of the profits in strawberry growing depends on the market. In several ways a good local market is most desired. The fruit can be handled riper. The grower comes to know his market and a reputation can be established whereby the same customers can be held year by year.

In a large city where a public market is maintained sales may be made often direct to the consumer and peddling by the grower is wholly unnecessary. Even in the smaller towns this may be largely avoided if desired by dealing with the local marketmen.

Many of the best strawberry growing regions, however, are so situated that distant markets must be depended upon. In some cases the careful grower establishes a reputation for first class fruit in one or more distant cities and makes all shipments direct to the dealer. Where this or some other plan is not followed the commission man is usually employed with whom the profits are shared in the form of a percentage .

The establishment of fruit growers associations in nearly all places that have become centers of production has greatly lightened the fruit growing business of the care and responsibility of marketing. This is particularly true where there is no large local demand and where distant markets must be depended upon. In this way the fruit grower can give his whole attention to the business of production and leave the marketing, a business in itself, in the hands of a qualified manager. In the selection of this manager the grower, if a stockholder has a voice.*

The association is able to save the growers a considerable amount by furnishing them with supplies at wholesale and in such quantities as desired. Another important feature of these organizations is the greater uniformity in packages and grading which have thereby been brought about.

These are a few of the features which together with the influence of the fruit growers associations, in bettering the general marketing conditions in favor of the grower, makes this one of the most desirable ways of disposing of the fruit crop.

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*See Bulletin No. 122, Colorado Experiment Station, Fruit Growers Associations.

RENEWAL OF OLD BEDS

Many of the leading growers of the strawberry in the Eastern states recommend taking but a single crop from a plantation. This means getting only one crop from the land during two years. Thus after the picking season is over the plants are plowed under and the land is prepared and planted to some late forage or other crop. This method also requires setting a new plantation each spring and keeping a double area of land in strawberries for at least a part of the time.

In this state, however, two, three and sometimes more crops are taken from a plantation in successive years. Some growers state that the second year's crop is often greater than that of the first year after setting the plants, while the third is apt to be inferior to the first two. The number of crops that can be harvested with profit appears to depend to a considerable extent upon the method of renewal, the care and freedom from weeds, and the use of fertilizing materials. In some cases six and seven crop's of berries have been taken from the same plantation before putting the land into other crops but this is not regarded as profitable.

Two methods of renewal, with some varations, were noted. In one method the old rows are narrowed down to about one foot by light plowing or deep cultivating between the rows. During the remainder of the season cultivation and irrigation are given the same as in new plantations, the runners being allowed to root along the sides of the rows until the spaces are only about one foot wide.

Additional thinning of the plants in the rows is frequently secured by "blocking" the old rows. This is done by hand with a hoe or by means of a cultivator run crosswise of the rows.

In the second method of renewal the rows are plowed along one side about one third only of the width of each row being left. The corresponding side of each row is plowed under and the next year the reverse side is thus treated. In this way all of the oldest and weakest plants are removed, and the next year the rows do not stand on the same land as the year before.

This method possesses two distinct advantages over the former. First, it allows of the breaking up and cultivation of the soil in the center of the old row which has become packed and hard. Second, the plants left to send out runners are younger and possess more vitality than those in the center of the old row and are therefore capable of producing better plants. This method seems better adapted to longer duration of the plantation than the former and is the one practiced by many of the most successful growers.

ROTATION

As soon as possible after the last crop of berries has been harvested the plantation is usually plowed under and the land is prepared and planted to some late forage or garden crop. Sweet corn, turnips or late cabbages are most frequently used for this purpose and in long seasons, roasting ears are sometimes obtained from the corn. If the soil is deficient in fertility, manure is often applied to the land before

plowing, in addition to the vegetable matter furnished by the old strawberry plants.

High priced land is usually planted the next year to some garden or truck crop such as tomatoes, cantaloupes, sweet corn, or potatoes. Raspberries are sometimes set on the land the second year to remain as long as they are productive.

Strawberries are often planted again after the third year of growing truck crops. Altho good strawberry land is by most growers considered too valuable for seeding to alfalfa or clover still some of the most successful ones believe it a very desirable thing to do. Where a good stand of red clover can be obtained it is particularly well adapted for this purpose as it is more easily subdued than alfalfa. In case the latter is plowed under it is usually necessary to remove the larger roots from the soil during the process of harrowing.

GROWING A SECOND CROP IN ONE SEASON

During the last few years a number of strawberry growers have succeeded in harvesting a second crop late in the Autumn usually during October. Strawberries at this season bring unusually high prices, some grown near Denver having been sold for $7.50 a crate.

One of the growers in this region follows the plan of mowing the foliage and allowing the patch to dry out as soon as the first crop is off. The old plants in the center of the rows are then plowed out after which the plat is disk harrowed in both directions. This is followed by a thorough soaking of the ground which starts the remaining plants into vigorous growth.

In this way the growth is first checked and then renewed with the result that the plants may blossom and fruit a second time frequently ripening the berries after the first fall of snow.

VARIETIES

Many of the numerous known varieties of the strawberry have been tried in different parts of Colorado. Only a few of these, however, have been found adapted to our conditions and it is often the case that one or two varieties are grown almost exclusively in a certain region. The ideal commercial berry for Colorado is yet to be found and a few growers are continually trying new varieties with the hope of finding one that shall be an improvement over those now grown. The qualities which recommend a variety for home use are not necessarily the same as those which make a desirable commercial variety. A good commercial variety should be hardy, very productive, of good color and firm enough to bear shipping well. It should possess good size and form and should not quickly run small after the first two or three pickings. A variety in which the fruit-bearing stems are strong and erect is found to possess a distinct advantage over one in which the berries are borne close to the ground where they are apt to suffer from sunscald following irrigation.

The mere fact that a variety does well on one farm is no guarantee that it will do equally well in all portions of that region nor even

that it will succeed on the adjoining farm. In most cases a variety which succeeds best in a certain locality may do so largely because of similarity in the soils and the location of the land together with any features which may influence climate.

The following list includes only such varieties as have been found best adapted to the prevailing conditions and practices in our principal strawberry growing regions.

Beder Wood.—(Perfect.) This is the leading variety grown in the Canon City region. Altho one of the earliest, it endures late frosts well. It is very productive, the cropping season is lasting and the size holds up well. The berries, which are medium to large, are borne on strong stems well above the ground. The color is scarlet, the quality excellent. Its principal fault is lack of firmness which unfits it for very long shipments. Probably our best commercial variety as yet for certain sections.

Glen Mary.—(Perfect.) One of the promising market varieties which is being tried in several localities. It is a vigorous growing, medium to late variety with large flattened-conical berries of dull red color and considerable firmness. It is productive but ripens unevenly, with a white tip.

Captain Jack.—(Perfect.) This variety is grown in several localities and is one of the leading sorts in the Denver region. It is a vigorous plant of stocky growth. The fruit is held above the foliage on upright stalks. Berries light crimson, regular form, fair quality and a good shipper. This is a good medium early variety but the berries soon become small after the first pickings. It has not been found as productive as the Beder Wood. Many growers find this variety requires a strong soil and it is recommended for damp, heavy land.

Gandy.—(Perfect.) A large, vigorous plant with few runners, well adapted to hill culture. The berries are large, irregular, bright scarlet, slow to ripen at the tips, quality and firmness good. This variety is quite commonly but not extensively grown as a late variety. It is considered as of moderate value.

Jucunda.—(Perfect.) This is the favorite variety in the Denver and Golden region and together with Captain Jack forms the principal market berry. There it is found productive, medium late and on bottom land the crop holds on well. It is a large variety, crimson color, good quality and firm flesh. This variety was not reported favorably in tests made at the State Experiment Station here several years ago.

Warfield.—(Pistillate.) This one of the older varieties which has been grown successfully in a commercial way in this state. It is vigorous, productive, and the fruit possesses excellent market qualities, being large, firm and highly colored. It must be planted with some perfect flowered variety for which purpose Beder Wood is recommended. It is also highly recommended for home use.

Marshall.—(Perfect.) A large fruited variety which has proven satisfactory to some growers. It requires extra care to get the best results which may be one reason why it is not more generally grown.

Aroma.—(Perfect.) This variety is reported by a few growers as one of the best market sorts on account of its good keeping qualities. It is not found to be quite hardy, however, and has not come into extensive culture.

Senator Dunlap.—(Perfect.) One of the good early varieties in some sections. It is especially prolific in the formation of runners hence this variety should be set farther apart than most varieties.

The berries are medium to small, conical, necked, and deep crimson. The quality is good but the fruit lacks firmness and turns dark on the market. The berries run small in latter part of season largely on account of the numerous runners sent out.

Ridgeway.—(Perfect.) A vigorous, mid-season variety of good productiveness. Fruit large, round-conical, bright crimson, quality good. By some of the prominent growers in the Boulder region this is considered their

best variety, its greatest fault being that the fruit is tender and does not bear shipping well.

Clarke's Seedling. This is one of the varieties which has won a reputation in Oregon from where it is shipped into this state. It is an attractive looking berry of great firmness and keeping qualities. Mr. C. L. Parsons, of Boulder, who has tested this variety reports it as being a poor producer in other localities.
on his place. It is worthy of further tests under different conditions and

Chesapeake.—(Perfect.) Plant vigorous and stocky, berries large, regular, rounded-conical form; color deep crimson, seeds yellow and prominent. This is a new variety producing fruit of excellent quality and firmness and of very attractive appearance. It is being tried by Mr. Joseph Hoyt, of Canon City. It is reported from New Hampshire as being a light producer. In other respects it possesses splendid commercial qualities and is especially promising for home use.

Wm. Belt.—(Perfect.) One of the large fruited vigorous varieties which has done well as a market berry on the heavier, moist soils near Longmont. This variety is also favorably reported from Michigan for its productiveness and vigor.

Splendid.—(Perfect.) This is a vigorous growing variety which forms full matted rows of stocky plants. The berries are large, light scarlet and ripen slowly at the tip. It is reported favorably as a producer for market near Denver.

Cost of Growing, Yields and Profit. The fact that but few of even the best growers keep any records of the expense of growing an acre of strawberries makes it difficult to give any exact statements in this connection. Mr. C. L. Parsons, of Boulder, kept records one year during which the total expense (not including rental or interest on cost of the land) was $105.00 for one acre of strawberries. Mr. J. P. Farmer, of Canon City, estimates that the equivalent of one man's time during summer with horse could care for five acres of berries except harvesting. He also estimates that it will cost $125 to $150 to grow an acre in the best manner, but believes that this is more than is usually put into the crop. In all probability $100 per acre is near the average expense of growing a crop of strawberries as practiced on a commercial scale in Colorado.

The profits in this industry are likewise a matter of great variability as they depend not alone on the cost of producing and harvesting the crop but also on the markets. It costs no more to grow a large yield than a small one. In the former case, to be sure, the cost of harvesting will be increased, and if a large yield is general the price is apt to be correspondingly low. Some general estimates of yields in the Canon City region range from 300 to as high as 800 crates per acre, the latter case being from small tracts. Bederwood in this region produces from 300 to 500 crates per acre in a good season.

From estimates given by growers in other regions and from other varieties it is evident that a crop of 300 crates per acre should be considered a good yield in a normal season.

The cost of harvesting and packing varies less widely than most of the other operations, and is estimated at from 60 to 65 cents per crate in places where pickers are paid 2 cents a quart. An average of the estimates secured on the cost of producing a crate of berries ready for market is about $1.15. The price received by the growers during the

last few years has averaged about $2.00 per crate. Some growers roughly estimate that about one half or 50 per cent. of the gross returns is profit during normal seasons.

INSECTS AND DISEASES

The strawberry is comparatively free from the insect pests and fungous diseases that infest this plant in many other regions. A few growers report the work of the strawberry leaf roller as occurring to a small extent, but not in sufficient amount to make spraying with insecticides necessary. The Experiment Station Entomologist, Prof. C. P. Gillette, states that but very little damage is done by insects upon the strawberry in this state.

Of the fungous diseases of the strawberry the leaf spot is the most common. It seldom occurs however, on vigorous beds in favorable situations to such an extent as to cause appreciable injury. In low, moist situations and on certain varieties it has in some cases been serious enough to call for spraying. Bordeaux mixture is used for this purpose, one application just before blossoming and one or two after harvesting the crop being recommended for this purpose.

A more serious and obscure trouble has been noticed by some growers as affecting the roots of the plants. It has been found most serious on land where the water level in the soil was close to the surface and where the physical condtion of the land is unfavorable for the plants. This trouble manifests itself in the blackening and dying of the roots of young plants before bearing, in some cases appearing at the beginning of the winter season. It also occurs on land that has been continually cropped with strawberries and other garden crops without rotation with some leguminous plant. Some study is now being undertaken here with the idea of determining if possible the cause and prevention of this trouble.

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GRAPE GROWING

BY

O. B. WHIPPLE

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GRAPE GROWING

By O. B. WHIPPLE

Grape growing has not been attempted in any large way by Colorado fruit growers, but it has been proven that the industry is profitable, even when attempted in an amateur way. It is an industry that offers quick returns and it appeals to the man who is waiting for his young orchard to come into bearing, also to the grower who likes to have a variety in fruit growing. Men who have followed grape growing persistently enough to have become practical grape growers are rare. In western Colorado, at least, grape-growing has been carried on in rather a haphazard way by the majority of the growers; or possibly we could express the situation better by saying, in a half-hearted way. The grower has not been altogether to blame; he has been at a loss to know what varieties to plant, how to grow them, or how to market the fruit after it has been grown. In the western part of the state the growers have been planting largely foreign grapes, those of the vinifera class. Many perplexing problems have come up and many growers have become discouraged. In the eastern part of the state the growers have been growing native American varieties and, possibly, with better success.

Vinifera grapes were introduced from California and the grower has naturally tried to adopt California methods of growing them. It has been necessary to modify these methods to suit Colorado conditions. In adapting their methods of pruning to our conditions several bad features have been developed and these, with an abundance of irrigation water, have caused the Colorado grape grower much grief. Yet there is no reason why these difficulties may not be overcome and the return will warrant a more careful study of the methods of growing.

Soils and Locations.—The grape must be planted upon a soil where the moisture conditions may be well controlled during the ripening period if it is to be expected to ripen its fruit properly. To ship well, and to keep well, a grape must be thoroughly ripened, it is hardly possible to get them overripe. A well drained, sandy soil is best, one that will dry out quickly as soon as the irrigation water is withheld. A gravelly hillside is an ideal location as far as the grape is concerned, but sometimes the grower objects when it comes to covering the vines for the winter. Any amount of gravel in the soil makes the covering more difficult. The grape must have plant food just the same as any other plant and it cannot be expected to thrive where other plants will not grow. A southern exposure will probably ripen the fruit a little better than a northern

exposure, yet the latter may be more desirable when looked at from all points of view. The vineyard on the southern slope may bud out earlier and is more subject to injury from late spring frosts. If one is choosing a location to grow grapes exclusively he should choose a locality where late frosts seldom occur and where the season is as long as possible. An early frost in the fall is as bad for many varieties as a late frost in the spring. Unless one can count on almost six months of growing weather it is hardly worth while attempting to grow many of the best varieties of vinifera grapes. Some of the early varieties will mature their fruit in five months of growing weather or even less.

Propagation.—Grapes are generally propagated from hardwood cuttings taken in the fall, stored over winter in moist sand in a cool cellar, and planted out in the spring. The cuttings are taken from well-matured one-year-old wood, each cutting generally containing two eyes or nodes. When such a cutting is set out in the spring the top bud is placed at the surface of the ground with the rest of the cutting buried. New canes laid on the ground and covered with dirt will root readily and form new plants, especially if the cane is barken or partially broken or cut in two at the point where it is covered. While the methods of propagation are simple most growers will prefer to let the nurserymen grow the plants. One-year-old plants may generally be bought for less than five cents.

Preparation of Land and Planting.—The common instruction given for the preparation of the land for the young orchard would apply equally well to the preparation of the proposed vineyard site. The ground should be plowed, preferably in the fall, and put in first-class condition. Ground that is plowed in the spring should be well worked down with the disc and harrow before it is planted.

The vineyard is generally set on the rectangular plan, either 8x8 feet or 8x6 feet. With the low bush method of training commonly practiced with vinifera grapes, setting the plants eight feet apart each way gives none too much room. With the trellis system of training the plants may be crowded to six feet in the row. Still I think it would be better to give them the full eight feet in the latter case.

The vines should be set at about the same depth at which they stood in the nursery, possibly a little deeper. They should be pruned back so as to leave only two or three eyes of the growth of one-year-old wood. The yearling plant properly pruned will consist of the main body (the original cutting) and generally one spur of new wood carrying two or three buds.

Cultivation.—The vineyard should receive good cultivation early in the season, for good cultivation is conducive to good

growth. And since we must check growth later in the season, that the fruit may ripen properly, it is important that we get as large a growth of both vines and fruit as early in the season as possible. The vineyard will profit by an occasional plowing, and if the land is not stirred well during the process of covering and uncovering it should be plowed some time during the fall or early winter. It may be plowed in the spring, but it will be more difficult to irrigate the first time. If the land is plowed from the time the vineyard is set, deep plowing will not injure the vineyard in any way. Early surface cultivation should be made to take the place of irrigation as far as possible. If the vines are not trellised the vineyard may be cultivated both ways to good advantage. One of the A-shaped single-horse cultivators will be found most convenient for vineyard word. After the first of August surface cultivation should be discontinued and the soil allowed to dry out.

Irrigation.—Really the irrigation of the vineyard is one of the most important operations in its management. The injudicious use of irrigation water is responsible for a greater part of the grape grower's grief. The tendency among growers is to use far too much water. The excessive use of water, although it may not be sufficient to actually injure the vines, is largely responsible for the loss from attacks by mildew and, more than anything else, for the poor shipping qualities of Colorado-grown vinifera grapes. One does not realize the importance of having the ground dry during the ripening season of the fruit until he has seen the grapes ripening in the California vineyards. Here the vines are robbed of half their foliage by the drought of late summer and, as a result, the flavor of the fruit is far superior to that of Colorado-grown grapes. The drought prevailing during the ripening season is at least partially responsible for the high sugar content of many California-grown grapes. A grape must carry a high per cent. of sugar to ship well; in other words, it must be well ripened. Still the Colorado grape grower is not altogether to blame, for if he were to allow his vineyard to dry out to the extent that the vines should begin to drop their foliage, his over-solicitous neighbors would go out of their way to advise him that the vines would surely die.

Two points should be observed in the use of water with reference to its relation to the growth of mildew. In the first place, the old system of running irrigation water near the rows and under the vines is a mistake. This plan wets the surface of the ground under the plants where it is slow to dry out and creates a moist atmosphere conducive to the growth of mildew. The grapes also drop down in this furrow and are covered with mud, which induces cracking and decay. A better plan is to run one furrow midway between the rows, make this furrow deep and avoid flooding the

Fig. 3. Shriveling of grapes due to excess of water

Fig. 4. Vinifera grape injured by sunburn

surface of the ground. When the vineyard is watered it should be watered well; then cultivate in the furrows, allow the surface of the ground to dry off, and conserve the moisture by frequent surface cultivation.

The vines should be kept growing well during the early part of the season, but after the berries are well grown, irrigation and cultivation should cease that the ground may dry out. The time for the last irrigation will depend much upon the character of the soil and upon the variety. Even though the foliage may turn yellow and begin to drop before the fruit is fully ripe, there is no cause for alarm; it will not hurt the vineyard and the fruit will ripen better. The cracking of berries is often due to the application of water after the fruit begins to ripen.

The grape will not stand excessive watering and the presence of free water in the soil is early indicated by a dropping of the foliage and a shriveling of the bunches. Fig. 3 is from a photograph of a bunch of Tokay grapes taken from a vineyard suffering from seepage from a ditch. A single heavy watering will often scald the foliage on some varieties. The ground should be kept in the same condition, as regards moisture, as soil for most other crops. The vineyard that has been well dried out during the ripening season will need a late fall watering to facilitate covering and to supply moisture to carry the plants through the dry winters. It is a general impression that the vineyard should not be watered during the blooming season.

Pruning.—The manner in which any plant bears its fruit largely determines the manner in which it shall be pruned. Yet it is surprising how few people are really observing enough to be able to tell you how the grape bears its fruit. The fruiting shoots of the grape spring from axillary buds, buds developed in the axils of the leaves the previous season. Then the one-year-old canes of the grape may be considered the fruiting wood. Axillary shoots from these canes bear from one to four bunches of fruit, the clusters of fruit arising from a joint opposite a leaf. Then, in pruning the grapevine during the dormant season, it should be pruned with the idea of removing as much of the old wood as possible, as well as to prevent over-bearing by removing a part of the new wood produced the previous season. Where the vines must be protected during the winter this is another matter that must be considered in pruning and training the vine. Then, too, it is well to remember that, with most varieties at least, buds near the base of the canes throw poor fruiting shoots and should not be considered.

There are, we may say, two general systems of grape pruning practiced. The one is to leave a large number of short canes and the other a smaller number of longer canes. With either system

the vine is equally well supplied with buds from which the fruiting shoots spring. In most cases the longer system of pruning or training is the more satisfactory. In Colorado it has been the practice to prune the vinifera grapes after the first method. The growers have adopted California methods and modified them to suit our conditions. In most localities it has been considered necessary to protect the vines during the winter, and a system of training similar to that shown in Fig. 1 has been worked out. The vines are trained in a low, bush form, leaving from six to twelve canes carrying four or five buds each. Canes not needed for fruiting wood are removed entirely or cut back to spurs with one or two buds that they may throw strong fruiting canes for the next season.

Fig. 1. Common method of training vinifera grape vines

The system has not been fully satisfactory, probably for more than one reason. In the first place, it is impractical to raise the frame-work high enough to keep the fruit off the ground, at least so long as we continue to cover the vines during the winter. Grapes that come in contact with the damp soil color poorly, are liable to crack and mold and are more subject to the attacks of mildew. Then the short system of pruning no doubt materially decreases the yield of many varieties. Were it possible to train the vines with a high stump, as is done in California, or train them on a trellis without protection, the plan might work better. The friut could be kept off the ground, and by spreading the frame-work it would be possible to increase the number of fruiting canes without getting the head too dense. The native grapes are generally trained upon a trellis and given no winter protection. It is the more common

practice, probably, to leave a frame-work of old arms and prune the one-year-old canes back to spurs carrying four or five buds. The number of canes left will have to be governed by the age of the vine and its apparent thrift. To be able to prune the vine intelligently the grower must have observed closely its behavior the previous season. If the new growth is weak and the fruit small it would indicate that the number of spurs left should be reduced. If the new growth is rank and the bunches large and poorly colored it is safe to leave more fruiting wood.

We have mentioned that buds near the base of the canes do not produce as well as those farther out. This is true of most varieties at least. The bunches are generally small and there are not so many of them on the shoot. The following table, taken from Bulletin 77, of the Tennessee Experiment Station, gives the average weight of fruit borne on shoots from the first twelve buds on the one-year-old canes. The first part of the table gives the average yields for single buds and the last part the average yields for groups of three buds:

AVERAGE OF FRUIT PER BUD ON MAIN CANE

BUDS—FROM BASE	1	2	3	4	5	6	7	8	9	10	11	12
	oz.	oz.	oz.	oz	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Concord	2.33	4.41	5.38	6.30	5.90	6.40	5.63	4.37	4.43	4.85	2.90	4.29
Niagara	.44	1.70	4.03	3.04	4.05	5.75	7.34	7.70	4.96	7.40	7.20	4.45
Deleware	.69	1.52	2.48	2.80	2.94	2.32	2.73	3.27	2.56	2.66	2.61	2.56
Brighton	2.15	3.37	4.28	5.23	7.91	7.69	11.14	11.13	8.56	12.04	6.78	6.84

	Buds 1–3		Buds 4–6		Buds 7–9		Buds 10–12	
Concord	Average	4.04	Average	6.20	Average	4.81	Average	4.01
Niagara	"	2.06	"	4.28	"	6.67	"	6.35
Deleware	"	1.56	"	2.69	"	2.85	"	2.61
Brighton	"	3.27	"	6.94	"	10.27	"	8.55
For All	"	2.73	"	5.03	"	6.15	"	5.38

It will be seen that up to a certain point the buds more removed from the base of the cane are the heavier producers. This table is compiled from data secured in one season and the author admits that a series of records taken during successive seasons may change it somewhat, yet it is surely worthy of being quoted. While the table gives the results of a test with four varieties of native grapes, it is safe to say that other varieties, native as well as vinifera, would show a similar variation. This, then, is an argument in favor of longer pruning.

It is easy to prune and train native grapes that require no pro-

tection during the winter, with canes eight or ten joints in length. But when we consider that a cane must be trained in a horizontal position to give all buds on the cane an equal chance, it is not so easy to work out a system of long training for grapes that need winter protection. About the only practical system is to start the new canes from as near the ground as possible and train them on a low trellis. In pruning native grapes it is a common practice to leave arms of old wood, train them in an upright position, and train the canes that spring from these arms along a wire. The plan of starting new canes each year from as near the ground as possible also works well if the canes are not trained too upright. Tied up to a stake or a wire trellis in an upright position, the lower buds do not get a fair chance with the rest, and shoots from the spurs left for the production of fruiting-wood fail to develop into strong canes. Fig 2 shows a vine pruned for this system of training; notice the spurs near the ground that are supposed to grow wood for another year. Some such system of training as this would no doubt prove very satisfactory for vinifera grapes in Colorado. If this system is adopted one must be sure and leave these short spurs and train the canes that are to produce the fruit-bearing shoots in as near a horizontal position as possible; in other words, use a low trellis, possibly a single wire. This gives the buds on the spurs plenty of light and all buds an equal chance. It has been demonstrated that the Sultanina and Alexandria will do well when pruned and trained in this manner.

Fig. 2.
Long Pruning of vinifera grape vines

Summer Pruning.—It is a common practice to summer prune vinifera grapes. In the first place one should go over the vines in the early spring and remove all suckers starting from below the ground and watersprouts arising from large arms. These shoots are generally sterile, take the strength of the vine and are poor fruiting canes if left for that purpose. One should go over the

vineyard often rather than allow all the suckers to grow until one general cleaning up. Removing any large amount of foliage weakens the vines.

The fruiting shoots should be pinched back a week or ten days before the blossoming period, the fruit seems to set better. It is a general belief that vines should not be pruned during the blooming season. If the vines are to be pruned with long canes, shoots that are intended for fruiting canes should not be pinched back or cut back. If the bush system of training as illustrated in Fig. 1 is to be followed, the vines are generally pruned back again after the fruit is set, sometimes twice. Summer pruning is weakening, especially if the shoots are allowed to grow long and are then slashed off at some distance from the tip. Such pruning is also liable to expose the fruit to the sun, and a sunburned bunch like that shown in Fig. 4 is the result. In all summer pruning the idea should be to prune by only removing tender growth. It would be safer to make the hired man use his thumb and finger for this pruning. If the grower wants to use a corn-knife, that is his business, but it is a shame to tempt a boy or a hired man by giving him such a tool.

Native grapes are generally suckered, but receive no further summer pruning.

Winter Protection.—In most parts of Colorado, the vinifera grapes need winter protection. In localities where one can rely on the minimum temperature not going below zero, well-matured vines will pass the winter without protection. American grapes are seldom given any protection, and possibly vinifera grapes would stand much more severe temperature if the vines were well matured by withholding water late in the season. The injury is more probably due to excessive drying out of the tissues, rather than to severe freezing; in other words, the immature canes freeze dry.

The vines are protected by giving them a light covering of earth. This covering need not be heavy, just enough to hold the canes down to the ground, if the vines are pruned long, or enough to cover the new wood of those pruned shorter. The vines are covered any time after they shed their leaves and before the ground freezes. They are uncovered in the spring after danger of frost is past. Yet the uncovering must not be delayed too long, lest the buds start and the tender, bleached growths may be broken off in the process of uncovering or killed by the hot sun afterwards. One may as well take the risk of having the shoots killed by frost as to leave them covered after growth starts. If they can be uncovered during a spell of cloudy weather, some of the tender, bleached growths may be saved. In covering large vines the plow is generally used to throw as much dirt to the vines as possible, and the job is finished with the shovel.

Fertilization.—The grape is not a heavy feeder, but on high soils it would no doubt respond to a light dressing of manure. Heavy applications of manure, however, are liable to stimulate the plant to make too rank a growth and then delay the ripening and impair the color of the fruit.

Picking and Packing.—Ripe grapes ship better than green ones, consequently they should not be picked before they are ripe. The fruit gains little, if any, in flavor after it is picked. The fruit should be picked when it is dry and fewer berries will be broken if it is picked during the heat of the day. Grapes should never be picked after a rain until they are thoroughly dry. The fruit should be picked into shallow boxes or trays and stacked in the packing house and allowed to wilt before any attempt is made to cull or pack it. The boxes should be stacked in a way to give the fruit good ventilation and the house should be well ventilated at night to keep it as cool as possible. The fruit should be allowed to wilt for at least one day. If packed too green the stems are loosened from the berries and it is hard to get the required weight in the crate. The bunches will be saved much rough handling if the pickers are provided with convenient shears for clipping the stems.

With the bunches properly wilted so they may be handled without breaking off the berries, they should be carefully gone over and all broken or imperfect berries clipped out with a pair of sharp-pointed shears. One must be careful to see that the inside of the bunch is all right. We sometimes find that compact bunches, apparently all right from outside appearances, are badly moulded near the center. Such a bunch soon spoils a crate of fruit. Small and imperfect berries are mashed easily and are a starting point for moulds. The stem of the bunch is generally clipped quite close to the cluster, but never so close but that it may serve as a handle to lift the bunch by. The bunches should be handled in a way to preserve as much of the bloom as possible.

Foreign grapes are packed in the common four-basket carrier used for apricots and plums. A tin form similar to that shown in Fig. 5 is used and the basket is really packed top first. In putting in the first bunches, which are to form the face of the pack, the bunch is picked up in a way to let the berries droop and then lowered into the form. In this way one builds up the face with no visible stems (Fig 7). The form should be well filled and when the four baskets are in the crate the face should stand high enough to hide the edges of the baskets, giving the crate the appearance of being packed solid. When the form is filled the basket is slipped over it and the whole thing is turned over, as shown in Fig. 6. It will be seen that the real bottom of the form is loose and in removing the form the fruit may be held firmly in place by holding

this bottom down with one hand. The face of the crate should show no stems, should practically hide the edges of the basket, and should stand high enough to give the top of the crate a slight bulge. Cleats on the bottom and top save this bulge from any pressure in stacking the crates. The packed crate should have a gross weight of twenty-eight pounds or more.

Fig. 5.
Tin form for packing grapes

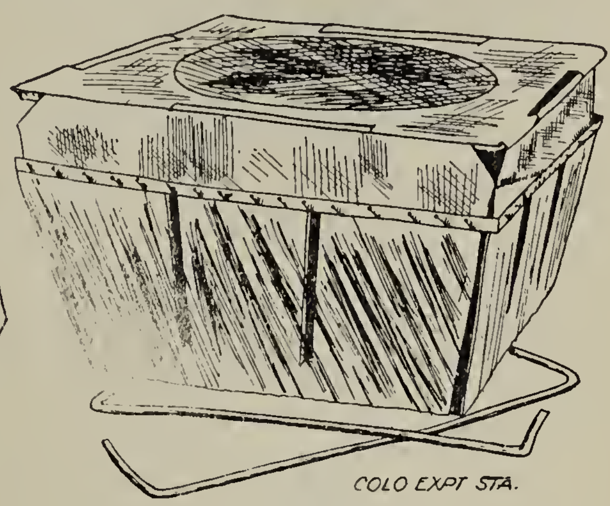

Fig. 5.
Transfer of grapes from form to basket

Native grapes are packed in eight-pound baskets. This basket is commonly called a ten-pound basket, but it holds only eight pounds of fruit. The basket should be well filled and faced as neatly as possible. The fruit should be culled as carefully as vinifera grapes.

VARIETIES.

The number of varieties of either vinifera or American grapes grown in Colorado is not large. Some of the best varieties of the vinifera grape apparently require a longer growing season than most parts of Colorado enjoy. None but the earliest can properly mature their fruit in the higher altitudes. Of these foreign grapes the Flame Tokay, Alexandria (Muscat of), Cornichon, and Sultanina (Thompson Seedless) are easily the favorites. Among the native varieties the Concord, Worden, Niagara, Moore (Early), and Agawam are the leading ones grown for the market.

The following description of leading varieties is not intended so much as an aid to the identification of varieties as to help the aspiring grape-grower to more intelligently choose varieties for planting.

VINIFERA VARIETIES.

Alexandria Muscat of).—Commonly called Muscat. Vine a moderately strong grower on good soil, quite prolific. Canes moderately short jointed; leaves not large, rather round, bright green above; bunches medium size, rather straggling and open, shouldered; berry oblong, greenish yellow to light yellow when well ripened, sometimes slightly bronzed, flesh solid and skin thick, flavor sweet and musky. Fruit ships well, quite attractive. Vine rather subject to attacks of mildew. One of the best grapes and will mature in a comparatively short season. Picked from September first to later in earliest sections of western Colorado, but it is seldom fully ripe before the middle of the month.

Black Hamburg.—This is another very promising variety. Vine strong grower; bunches large, broad at shoulder, rather compact; berries large, slightly oval, skin thick, almost black, firm and sweet. A good shipper and quite attractive, ripens just before Alexandria.

Cornichon.—Vine quite a strong grower, but rather bushy; canes

thick and short jointed; leaves large, dark green, deeply lobed; bunches medium to large, loose; stems long, giving bunch a drooping appearance; berry long, tapering at both ends, dark blue when fully ripened; flesh solid, skin thick; flavor good. Good shipper, and attractive, but can only be matured in localities where one can count on six months from frost to frost, later than Flame Tokay.

Flame Tokay.—Vine a strong grower and a heavy bearer; canes strong, with long internodes or joints; leaves large, dark green, only moderately lobed; bunches large, often weighing five pounds or more, fairly compact, well shouldered; berry large, oblong with rather a flat tip with pistil scar persisting, rather a coppery red, with thin bloom; flesh solid and flavor very good. Fruit a good shipper and attractive. Colors best on rather light soil, fairly free from mildew and a desirable variety where the season is long enough. About thirty days later than Alexandria or (Muscat).

Malaga.—This variety has been little grown in Colorado. It is a white grape maturing only a little later than the Alexandria. A good shipper and one of California's favorite table grapes. California-grown Malagas are found on our markets at Christmas time. May be worthy of more thorough trial in Colorado.

Peru (Rose of).—Black Malvoise, and Zinfandel have been planted. The last two are rather early and soft, split badly in damp weather and mould in shipment. The first is a fair variety, but neither of the three should be considered in a commercial vineyard.

Sultanina (Thompson Seedless).—Vine strong grower and very prolific; canes thick, rather long jointed; bunches long and loose, often a foot long or longer, shouldered; berry small, oval, light yellow, transparent; flesh firm, skin thin, flavor sweet, seedless. Ships well, quite attractive, and would sell well in quantities. Can be easily dried and makes excellent raisins. Variety well adapted to the longer system of pruning.

AMERICAN VARIETIES.

Agawam.—Generally classed as a native grape, although some authorities place it as a hybrid between one of our native grapes and the foreign vinifera. A good red grape slightly earlier than Concord. Has a rich musky flavor and is a good market grape.

Concord.—This is the old standard native grape. It is a black grape of good quality. Vine a good grower and prolific. Ripens about with the Alexandria.

Deleware.—This grape is quite commonly grown. It is a good early variety with a nice flavor. Bunch and berry small. A good bearer, color red.

Moore (Early).—A good early black grape.

Niagara.—A good white grape of good quality. A good bearer and sells very well. A late grape, requiring too long a season to be adapted to higher altitudes. Ripens about with Flame Tokay.

Worden.—A variety a little earlier than the Concord. Berry slightly larger and softer. A black grape of good quality. A good one for home use or for market.

INSECTS AND DISEASES.

Insects.—Very few insects are troublesome to the grape grower in Colorado. Grasshoppers are about the only insect that has been reported as doing any serious damage. They generally migrate into the vineyard from a nearby field where their food has been cut or destroyed in some way, and often in such numbers as to do serious damage before their work can be checked. Early in the season it is possible to kill them by spraying the vines thoroughly with arsenate of lead. This is not always satisfactory, however, as the hoppers work a great deal near the center of the vines where it is difficult to apply spray, and they may do serious damage by girdling canes before they get a fatal dose of poison. Then it is objectionable to spray late in the season with such a poison. A good plan

is to distribute bran-mash on the ground about the vines. This is prepared by mixing forty pounds of bran, one pound of white arsenic, one pint of molasses, and enough water to moisten the whole mixture.

Diseases.—Of the diseases injurious to the vineyard, powdery mildew (U. Spirali) is no doubt the most dangerous. The fungus attacks the leaves, canes, and fruit; but it is on the fruit that it does serious damage. On the leaves it first appears as frosty patches and these later appear as bronzed areas on the upper surface. On the canes it appears very much the same. On the green fruit it appears as a velvety, white coating on the berries and stems. The fruit is checked in its growth, often cracks open, and is ruined for market. On the mature fruit it may only be detected by a slight bronzing of the surface of the white varieties. It softens the skin of the mature fruit and the berries are easily broken in the process of packing, thus giving entrance to other moulds.

This disease may be checked by dusting the vines with dry sulphur or spraying with either the Rex lime-sulphur or home-prepared lime-sulphur washes. To be effective, sulphur must be used during the warm weather. It is best applied with some sort of a blower or bellows, but may be sifted from a cheesecloth bag. In applying it in this crude way care must be taken to not get it too thick, as it will burn the foliage where it collects in the hollows of the leaves. The liquid lime-sulphur sprays are applied with any convenient sprayer. Commercial Rex lime-sulphur is used in strengths

Fig. 7
Full packed basket

Fig. 8
Black knot of grape

varying from one gallon to forty gallons of water to one gallon to sevnty-five gallons of water. The latter strength seems to give as good results as the stronger. Home-prepared lime-sulphur may be prepared by boiling three pounds of good lump-lime and three pounds of sulphur in a small quantity of water for forty-five minutes and diluting the whole to fifty gallons.

Applications for mildew are seldom made before the fungus makes its appearance, but as soon as it does appear it is time for action. It is nice to have faith in ones country to think that cannon breezes will take care of grape mildew, and men have been known to make such a boast, but a light shower and a few warm days afterwards have often proved that such faith is unwarranted. Delays often mean serious loss and it is better to check an attack early rather than wait until the fruit is full grown.

The mould that most commonly attacks the fruit in transit or where it lays on the ground in the vineyard, is the common fruit mould, (Mucor Stolonifer Ehreub).

Crown gall probably destroys a few vines each year, but in many cases frost injury has probably been confused with this trouble. Crown gall is identified by a growth of gall either at the surface of below the surface of the ground. The galls are as much an outgrowth of the wood as of the bark. There is no remedy, and affected vines should be removed. Frost injury is readily distinguished from crown gall in that the wart-like growth

is an outgrowth of the bark alone. The nature of the growth would suggest that the cambium layer has become active during the warm days of early spring and was later injured by severe freezing. The freezing has apparently caused a separation of the wood and bark and the callus is tissue laid down by the bark in an attempt to heal the wound. The nature of the growth is well illustrated in Fig. 8. Canes severely injured seldom start any strong growth from above the injury.

Cost of Growing and Returns.—Few growers are able to give accurate data as to the cost of growing and marketing grapes. The following estimate of the cost of growing vinifera grapes is furnished by one of the most careful and one of the most successful growers in western Colorado. This does not include the expense of picking and packing, at least five cents per crate, and the cost of the crate and baskets, fifteen cents. The vineyard should be in full bearing in its fourth season. This estimate is probably the maximum in both expense and production:

ESTIMATE.

First Year, Expense—

680 Vines, 8 feet apart, at 2 cents	$13.60
Plowing and leveling	3.00
Planting, 2 days at $2.50 per day	5.00
Cultivating, 4 times at $1.50	6.00
Irrigating, 4 times at $2.00	8.00
Pruning and covering, 2 days at $2.50	5.00
	$40.60

Second Year, Expense—

Uncovering, 1 day	$ 2.50
Four irrigations, at $2.00 each	8.00
Four cultivations, at $1.50 each	6.00
Pruning and covering, 2 days at $2.50 per day	5.00
	$21.50

Early bearing varieties will produce perhaps 50 crates at $1.00 per crate, $50.00.

Third Year, Expense—

Uncovering, 2 days at 2.50 per day	$ 5.00
Four irrigations, at $2.00 each	8.00
Three cultivations, at $1.50 each	4.50
Pruning and covering, 3 days at $2.50	7.50
	$25.00

Will yield about 300 crates at $1.00, $300.

Fourth Year, Expense—

Uncovering, 2 days at $2.50 per day	$ 5.00
Four irrigations, at $2.50 each	8.00
Two cultivations, at $1.50 each	3.00
Pruning and covering, 4 days at $2.50	10.00
	$26.00

Will yield about 680 crates at $1.00 per crate, $680.

Returns from the vineyard will vary according to the care it receives. The vinifera vineyard, in good bearing, should produce about a crate of fruit to the vine, or close to seven hundred crates per acre. The average price received for these grapes is probably seventy-five cents per crate f. o. b. Native grapes should produce close to 2,500 baskets per acre, if the vines are properly cared for. The average price which the grower receives per basket will possibly be close to twenty-five cents.

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Tillage, Fertilizers and Shade Crops for Orchards.

BY

WENDELL PADDOCK.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

RED CLOVER AS A SHADE CROP.

Tillage, Fertilizers and Shade Crops
for Orchards.

WENDELL PADDOCK.

Clean cultivation has been practiced by the majority of our orchardists from the time the first trees were planted. It would be difficult to explain just why this plan has been followed but it is probable that it was brought to us from California. While a certain amount of cultivation is necessary we wish to state emphatically that we do not believe in any system by which the soil is exposed to the action of Colorado sunshine during the heat of the summer. In fact, we believe that this practice has been very much over done and the older orchards are in some cases beginning to show the effects. We may well profit by the experience of fruit growers in other states and in this connection the following quotation should be instructive:

"For a quarter of a century great areas of vineyards yielded thousands of tons of grapes. All these years, under the stimulus of success, these same areas of land received clean, annual and (may we not truthfully add) merciless cultivation. The natural fertillity of the soil was gradually reduced by enormous crops of fruit and its physical condition lowered year by year, without the restoration of any considerable amount of plant food or vegetable matter. After the lapse of many years, from various troubles and diseases, the vigor and fruitfulness of the vineyards waned and the industry began to languish. Hundreds of acres of vines were pulled out and the land immediately and without improvement set to peach trees which, for another long term of years, and under the usual relentless culture without the addition of humus in any form, thrived and produced numerous, heavy crops of fruit. Again, as the remaining store of fertility became further depleted by the searching root systems of adult peach trees, enemies began to appear and make their presence felt. San Jose scale and leaf curl fell upon the Island as a scourge and came near writing the final chapter in the history of successful peach culture there. With the destruction of great areas of orchards by the scale and the injury of thousands upon thousands of trees, upon which the scale was not quite successfully combated, it is only natural that great discouragement and depression should overtake the orchardists, so long accustomed to bountiful rewards for labor performed under such favorable conditions."

Has not Prof. Green* truthfully portrayed what we have a right to expect will happen to Colorado fruit growers if our system of orchard management is not changed? No sane man should hope to continue to take large crops of first class fruit from an orchard for very many years without doing something to restore the lost fertility. True we do not expect to have the San Jose scale or the peach leaf curl to contend with, but both are possibilities. We have however been faithful in giving clean cultivation and when one comes to think of it,

*Green, W. J. and Ballou, F. H., Ohio Expt. Sta. Bul. 157, p. 118.

do not the expressions, "merciless cultivation" and "relentless culture" aptly describe this system?

Prof. Bailey** has summarized the benefits of tillage as follows:

1. Tillage improves the physical condition of the land.
   (a) By fining the soil, and thereby presenting greater feeding surface to the roots;
   (b) By increasing the depth of the soil, and thereby giving a greater foraging and roothold area to the plant;
   (c) By warming and drying the soil in spring;
   (d) By reducing the extremes of tempreature and moisture.
2. Tillage may save moisture,
   (e) By increasing the water-holding capacity of the soil;
   (f) By checking evaporation.
3. Tillage may augment chemical activities,
   (g) By aiding in setting free plant-food;
   (h) By promoting nitrification;
   (i) By hastening the decomposition of organic matter;
   (j) By extending these agencies (g, h, i) to greater depths of the soil.

A composite of the practices of a number of the most successful fruit growers results as follows: Use the turning plow in the spring, each year or often enough to prevent the ground from becoming hard. Follow the plow with a harrow or disc, if lumpy, and this with the smoothing harrow. Some use a float instead of the harrow. The subsequent cultivation consists in going over the ground often enough to prevent a crust from forming and to keep the weeds down. This necessitates cultivation after each irrigation and after rains. The Planet Jr. cultivator and the smoothing harrow are used for this purpose. Cultivation is continued until the branches are bent down by the fruit which will average about the first of August.

Winter cultivation is practiced when the condition of the ground will permit. Two cultivations during the winter is considered to be about right. The Planet Jr. or a disc harrow is used for this purpose.

Turning now to the classification of the benefits of tillage it would seem at first thought that the system followed by our best orchardists met all requirements. We find first that tillage improves the physical condition of the land. By the physical condition is meant its tilth and general make up, whether it is compact and heavy or whether it is loose and loamy. But any one who has traveled about among the orchards knows that in the majority of cases the soil is far from being loose and loamy. On the contrary, it soon becomes compact, lacks fibre and it becomes puddled after irrigation or rains. We have even seen orchard soils so hard two inches below the surface that an opening could be made into it only with the aid of a pick. And yet thorough cultivation had been given the land for years. Evidently something is wrong, so we follow on down the classification and find under i, that tillage may hasten the decomposition of organic matter. Here we believe is the cause of our difficulties. Cultivation, bare soils and intense sunshine do hasten decomposition

**Bailey, L. H. The Principles of Fruit Growing p. 139.

and in fact the burning up of such material. The classification is correct but we have failed to adapt our system of cultivation to the climatic condition.

We are absolutely dependent upon decaying organic matter to keep the soil in proper physical condition; that is loamy and friable. But upon examination we find that this material is largely absent, having been literally sacrificed as a burnt offering to the gods of clean cultivation.

A certain amount of cultivation is necessary but one need not wear out his soil in an effort to supply it. As will be seen in the following pages, we advocate growing a shade crop in the orchard during hot weather. If this system is adopted, the land should be plowed at least every second season, depending upon the soil. By so doing a sufficient amount of cultivation will be given the land and at the same time organic matter will be supplied.

In the case of young orchards, unless the ground is very poor, some hoed crop will probably be advisable. Such crops shade the soil and their growth need not interfere with the proper development of the trees. Among the crops used are cantaloupes, potatoes, squashes and corn.

We often hear it said that Colorado soils are well nigh *inexhaustable, and indeed it is true that they are fairly rich in many of the elements of fertility. But we now know from experience that land cropped year after year to wheat becomes unprofitable, even the second crop of potatoes is rarely satisfactory and all fruit association men and local dealers know that small apples and pie peaches are becoming more and more common. In several sections of the state the land was planted continuously to wheat in the early day and as any one would now expect the soil became exhausted and in some instances the farmers faced bankruptcy. This same land is now producing immense crops of wheat, oats, sugar beets, potatoes and alfalfa. What has brought about the change? Alfalfa was introduced about the year 1863. It was adapted to our conditions from the first and soon large areas of this land were growing luxuriant crops of this unexcelled forage crop. The feeding of animals was then in its infancy and alfalfa soon became a drug on the market. It was then found that alfalfa sod could be successfully broken and much to the surprise of

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*Some of our readers have no doubt seen the papers on various phases of soil fertility published during recent years by the Bureau of Soils of the Department of Agriculture. This bureau is attempting to show that there is no such thing as soil exhaustion as is generally understood, but rather that there is an inexhaustable supply of all of the mineral elements of plant food in all soils at all times. They contend that the decreased yields of the various crops is due to poisonous substances excreted by the roots of plants. Thus, according to this view, any crop will soon poison the land to such an extent that proper development of the plants is hindered and decreased yields result. The remedy according to this theory is, naturally, a proper rotation of crops. The idea that the roots of plants excrete poisonous materials is an old one and one which we believe to be true with some plants at least. But that this is accountable for all of the many cases of unsatisfactory yields is difficult to believe. At any rate the writer prefers for the present to adhere to the well established theories, believing that the available supply of plant food may be depleted and that the texture of the soil counts for much. The presence of decaying vegetable matter in the soil improves its physical condition, helps to set plant food free and in a measure takes the place of crop rotation in the orchard. This may best be supplied and conserved under arid conditions by the use of shade crops.

all, when planted to wheat the yield per acre was far greater than when the land was first subdued.

Now what had the alfalfa done to the soil? It had actually added some nitrogen which by the aid of the nitrogen fixing bacteria it is able to gather from the air. It also brought up from the lower depths of soil, ten or more feet below the surface, potassium and phosphorus. These two important elements of plant food were deposited in the surface soil in the shattered leaves and stems as crop after crop was removed from the soil and when the sod was broken the decaying roots and stubble added their quota. But more important than all these, decaying vegetable matter and its products had been added to the soil. Without decaying vegetable matter the physical condition of the soil is almost ruined for agricultural purposes and the host of bacteria which perform many essential activities are prevented from developing.

Our orchards have, for the most part, been planted on desert land and in most cases the land was cleared of the native growth and planted directly to trees. Thus there was little or no vegetable matter in the soil and, since our growers have been very insistent on clean cultivation and stable manure is scarce, but little has been added. Now does it not stand to reason that continued croping to apples or to peaches will bring the same disastrous results that befell the wheat growers mentioned above? The following table complied by Dr. Roberts* is valuable in this connection. Table I shows the amounts of plant food elements which are removed in the grain and straw in twenty years of continuous cropping to wheat. It is assumed that an average of 15 bushels of grain and 35 pounds of straw are removed from an acre each year.

Table I. Amounts of Plant Food Removed From an Acre in 20 Years Continuous Cropping to Wheat.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Grain	424.80	160.20	109.80	$79.86
Straw	234.78	50.40	214.20	48.37

In contrast with this the same author gives similar figures of the amounts of plant food which may be expected to be carried away in 20 years in fruit and leaves from an acre of bearing apple orchard. The figures represent 20 years of the productive life of a New York apple orchard between the ages of 13 and 33 years and does not include the materials stored in the wood of the tree.

Table II. Amounts of Plant Food Removed From an Acre of Apple Orchard in Twenty Years.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Apples	498.60	38.25	728.55	$110.26
Leaves	456.75	126.	441.	97.17

Total value in wheat, grain and straw for 20 years $128.23
Total value in apple, fruit and leaves for 20 years 207.45

These figures show that an apple crop takes more fertility from

*I. P. Roberts, Bull. 103, Cornell Experiment Station.

the land than wheat and most farmers know from experience that continued cropping to most farm crops leads to disaster. The day of reckoning does not come quite so soon, perhaps, with mismanaged orchards but it is none-the less certain. The fact that trees grow to great size and live for many years in forests, does not apply to growing apples, unless, perchance, they are grown for cider. The quicker the fruit grower realizes that each crop of fruit makes large inroads upon the available supply of plant food the quicker will he awaken to the fact that scrupulously clean cultivation is not all there is in the handling of orchard soil.

There are 38 elements which enter into the make up of a plant; 10 of this number are essential to its proper growth. These elements are as follows: Carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, and iron. Normal development of a plant is impossible if a single one of these elements is absent. Only three of this number are considered, ordinarily, in the fertilizing of soil; namely, nitrogen, potassium and phosphorus.

Nitrogen is essential to vigorous growth in plants and an oversupply in the soil often promotes a rank growth of twigs and foliage at the expense of fruit production.

Potassium or potash is especially important in fruit growing since it aids in developing color and is the base in combination with fruit acids. It also forms more than 50 per cent. of the ash of fruits and constitutes a large proportion of the ash of the wood of fruit trees. Phosphorous is not so important in fruit growing as in grain production as it enters largely into the composition of seeds. But it is an essential constituent of tree and fruit and aids particularly in the proper ripening of the latter.

These substances are supplied in various forms in commercial fertilizers and it would seem to be a simple matter to supply any one or all of them as the individual orchard seemed to demand. Such manures are used very extensively by orchardists in the eastern states, but so far as we know commercial fertilizers have not been tried in the orchards of Colorado and we hope that their use will not become necessary for many years to come. In any event, freight rates are so high as to make their use almost prohibitive, and then, the benefit to be derived from their use under Colorado conditions is problematical as the following experience would indicate.

Potato growers feel that they should grow two crops in succession after turning under alfalfa sod. The second crop, however, is rarely as good as the first and is very often produced at a loss. To one who is familiar with farming methods as practiced in the East it would seem to be a simple matter to bring up the yield of the second crop by an application of commercial fertilizers. Accordingly a series of acre plots were laid off in a potato field at Greeley to which commercial fertilizers were applied. High grade nitrate of soda, sulphate of potash and phosphoric acid in the form of dissolved bone meal were secured and applied separately and in various combinations. These experiments were carried through four years and at the end of that

time it could not be shown that the fertilizers had in any case produced an increased yield over the unfertilized plots.

How then, are we to maintain the fertility of our orchard lands? We have already seen what the benefits are of plowing under alfalfa to wheat and potatoes, so why not adopt a system of green manuring for the orchard? The Greeley potato growers do not think of growing more than two crops of potatoes after alfalfa has been turned under. If they can afford to grow alfalfa for the purpose of producing better potatoes and in the meantime get but two crops in five years, surely the orchardist can adopt similar methods. There will be no rotation with the orchard crop but an actual saving in labor may be made in that there is little or no cultivation while the green manure is occupying the ground. The potato grower gets some returns, to be sure, from the alfalfa hay and from the grain with which it is seeded but the potato crop is the money maker.

We have already noticed what some of the effects of plowing under green crops are. But the importance of the subject will warrant a repetition. The following summary has been adapted in part from Professor Bailey's writings on cover crops:

I. Green manures improve the physical condition of the land:
  - Shade the surface soil from intense sun in summer thereby protecting the trunk and limbs from the reflection of the sun from the soil; prevent the very rapid burning of organic matter in the soil; conserve some of the surface moisture, and prevent crusts from forming.
  - Prevent soils from cementing and puddling.
  - Prevent the rapid drainage of water from loose, porous soils.
  - Prevent one form of freezing dry.

II. They catch and hold some of the leaching nitrates;
  - Render plant food materials available;
  - Appropriate nitrogen if legumious crops are grown.

Cover crops have become very popular in the East in orchard management. The name is derived from the fact that the seed is sown in the fall or late summer and sufficient growth results so that the ground is covered and protected during the winter. The crop is intended primarily for a green manure but under eastern conditions it cannot occupy the land during the growing season. The trees usually need all of the available moisture during that period and clean cultivation is practiced to conserve it. As soon as the trees have made their growth for the season the cover crop is planted and its growth uses up the surplus moisture and thus the trees are aided in maturing before cold weather comes on. Colorado conditions are quite different from the fact that the water is largely under man's control. We believe that our conditions demand a cover for the soil far more in the summer than during the winter. And moreover, nearly as much protection is afforded during the winter if the crop is plowed under late in fall, as is the case when the plants are allowed to stand. We therefore propose the name, *shade crops,* for a system which we hope may come into general use in this state.

Many orchardists have seen young trees killed by running water close to them during a hot day; the reflection of the sun from the

water causing sun scald. It is thought that reflection from a hot, baked soil may cause similar injuries.

As has been noted before, Colorado soils are very deficient in decaying vegetable matter and it is very rapidly dissipated when it is supplied. A summer cover will preform one of its most important functions in preventing, at least a portion of this loss.

Examine a moderately heavy soil in an orchard where a manurial crop is growing. The surface soil under the plants will be found to be cool, moist and friable, while adjacent unprotected land will be found to be hot, dry and compact. This difference is due not alone to the shade afforded by the plants but to the transpiration of immense quantities of water as well. It has been found, for instance that a grass plant will give off its own weight of water every 24 hours in hot, dry summer weather. To be sure it requires more water to irrigate an orchard where any crop other than the trees is grown, but where sufficient water can be had for irrigation this feature need not be considered.

It is a well known fact that our heavier soils, particularly if they are strongly alkaline, become so compact that it is almost impossible to cultivate them after the first irrigation in the spring. It is also true that continued clean cultivation, particularly if plowing is omitted, will make almost any of our soils compact. It is this condition that prevents the proper development of absorbing roots and the setting free of the native fertility of the soil. A few of our fruit growers have shown that green manures in combination with the necessary plowing, will work wonders with such soils as well as with the appearance of the trees growing on them.

Earth worms do damage in some orchards for the reason that they puddle the soil and much of the irrigation water seems to disappear through the channels which they make deep in the ground. A supply of decaying organic matter should do much to overcome these effects.

Soils are occasionally found which are so porous that water leaches down through them much like a seive. If fiber can be incorporated in such land by plowing under green crops this tendency will be overcome, to a certain extent at least.

Many young trees are lost each year in the colder districts as a result of "freezing dry." This term is used as a name for a condition which may be induced in different ways. The usual cause is simply a lack of water in the soil during the winter. Trees give off water during cold weather from twigs and limbs, and if the supply is not replenished, death results. A similar effect is produced when a damp soil is frozen to such a depth that root action is suspended. The tops of such trees usually die after a feeble attempt at putting forth leaves has been made, while the roots are usually in perfect condition.

The condition mentioned first, may be avoided by winter or late fall irrigation. The deep freezing of soil presents more of a problem but we believe that it may be prevented to a considerable extent by the use of shade crops. True, the system we propose contemplates plowing in the fall but eastern experience proves that as much pro-

tection from frost is secured when a crop is plowed into the land in the fall as when it is left standing throughout the winter.

The winter of 1903-4 was very severe in the East and in some sections hundreds of orchard trees, particularly peach trees, were destroyed. Prof Green* made a survey of the injured orchards the following summer and found that injury occured only on impoverished and bare soils. A cover crop, sod, good growth of weeds, or stable manure afforded almost complete protection from the cold. And moreover, and what is more important for our purpose he found that where such materials had been plowed under recently, the protection was just as efficient.

Popular writers on horticultural topics have woefully confused humus with decaying organic matter and have implied that all organic material is humus as soon as it is mixed with the soil and decay has set in. The fact is, humus is the final product of organic decay and as such has entirely different effects on soils than have organic materials which are undergoing the processes of decomposition.

When green manure is plowed into the soil various low forms of plant life including fungi, yeasts and bacteria attack it thus inducing decay. [1]Fraenkel "found in the cultivated soil of Liebefeld 5,750,000, in meadow land 9,400,000, in a manure pile 44,500,000 bacteria per cubic centimeter." These figures seem high for so small a quantity of material, but taking the average size of a bacterium, a cubic centimeter might readily contain six hundred millions.

Other forms of bacteria begin to multiply as soon as fermentation sets in. Different organisms have different and important functions to preform in promoting chemical activities in the soil; plant food elements are set free, changed and combined into substances which plants can use. No less than five different acids are generated by the processes of decay, carbonic acid being among the more important. [2]Sackett found that clover taken in full bloom in June when ground and mixed with soil at the rate of 10 tons per acre, gave off, at the end of three days, [3]carbon dioxide corresponding to 3812 pounds per acre foot. This action continued through a period of three weeks, gradually diminishing however until at the end of that period very little of the gas was evolved. One hundred tons per acre of red clover treated in the same manner gave off after 12 days five tons of carbon dioxide per acre foot. This investigator also tested the solvent action of pure carbon dioxide on various materials. Pure ground bone meal was placed in a flask and carbon dioxide was allowed to pass through it. At the end of one hour 2.11% of the insoluble phosphoric acid had been made soluble. At the end of two hours 5.21% was made soluble. Ground phosphate rock treated in the same manner gave the following

*Green Bull. 157 Ohio Agri. Exp. Sta. 1904.

[1] Hilgard, Soils, p 143.

[2] Sackett, W. G., unpublished notes.

[3] Carbon dioxide and carbonic acid gas are synonymous; when combined with water, carbonic acid is formed.

results: after one hour .16% of the insoluble phosphoric acid had been made soluble; in two hours .28%. Magnesium phosphate similarly treated yielded 16.33% in one hour and 22.35% in two hours of soluble phosphoric acid.

Carbonic acid is, then, an important agent in dissolving rock particles and with its aid, latent fertility is brought into a condition which plants may use.

Organic matter is often almost entirely consumed under arid conditions very quickly after it is incorporated with the soil. The heat of the sun in conjunction with insufficient moisture, produces conditions which oxidize the matter, or in other words, burn it much as though it had been consumed by fire, hence the burning out of soil, an expression common among farmers. This change in organic matter is no doubt begun by soil organisms while the later stages are probably of a chemical nature.

The decay which results in humus, takes place at moderate temperatures. Organisms do not develop in a low temperature and if it is too high, oxidation or burning results. An apparent contradiction to this statement is found in the difficulty with which unrotted stable manure decays when plowed into land, if moisture is not abundant. The lack of moisture probably prevents the development of bacteria in sufficient numbers to begin decay, consequently the chemical changes which result in burning do not occur. The presence of such material is a detriment to growing plants as it keeps the soil so open that an undue amount of moisture is permitted to escape. This effect is so noticeable that many of the so-called dry farmers make no use of stable manure. This wanton waste might easily be prevented by composting as there is sufficient moisture in the rain and snow to thoroughly rot manure treated in this manner.

The compound resulting after organic decay is completed is humus. Such decay results in a dark colored material, without organic structure, soluble in alkalies after the lime has been removed. Humus gives a dark rich color to otherwise light colored soils. It is complex in composition and is especially important as being a reservoir of nitrogen. Much of the nitrogen that is brought to the soil by leguminous plants, as well as that which is stored in the plant in the process of growth, is not made available to growing plants until the humus stage is reached.

Humus usually exists in small quantities in arid soils but often is entirely absent where clean cultivation without manuring has been practiced. It may also be present in small quantities along with partially decayed organic matter. Much of this valuable material is lost by constant clean cultivation and the consequent burning of the organic materials, before it reaches the stage where humifaction may take place.

A large part of the loss could be prevented, not only of nitrogen but of the many benefits to be derived from decaying organic matter and humus as well, by shading the soil.

While it is no doubt true that humus does aid in improving the physical condition of the soil, it is probable that most of the beneficial effect, such as giving fibrè, and tilth as well as increasing the water holding capacity, is due in a much larger degree to the partially decayed organic matter.

By leguminous plants is meant the family which includes the beans, peas, clovers, alfalfa and vetches. These are the only plants of importance so far as now known which have the power of taking nitrogen from the air and converting it into combinations which other plants can use. Thus they actually add plant food to the soil and nitrogen is the most expensive element to supply in commercial form as well as the most difficult to keep, since it is readilly dissipated in gaseous form. The manner in which such plants take nitrogen from the air was a mystery for a long time. It was finally determined that a certain species of bacterium lives on the roots of vigorous legumes where the swollen regions or tubercles are formed. This low form of plant life is able to take the free nitrogen from the air and change it into forms which plants can use. Consequently legumes can be grown on land from which nitrogen has been exhausted.

It was also found that leguminous plants do not thrive in soil where the accompanying bacteria are absent. This led to the making of pure cultures of the bacteria which are now supplied in commercial form. These cultures after being diluted and sufficient multiplication of bacteria has taken place, are sprinkled over the land, or better still, seeds are soaked in the culture material just before planting.

Such cultures have not been the success that was anticipated but in the meantime a mass of overdrawn articles on the subject has been printed in magazines and papers. The result has been that many farmers have been lead to believe that by simply applying the cultures to their land wonderful benefit would result to any and all crops. The truth is, these cultures have no direct effect on any plants other than the legumes. And moreover, should one wish to secure such material he must designate the particular crop he intends to grow. Cultures from clover bacteria would not be expected to have any effect on beans or alfalfa. It would be idle to apply these cultures to land which is already producing good crops of any of these plants.

What crops shall be grown for shade crops and how shall they be handled? This is a difficult question to answer as the practice is new and but little has been learned as yet about the subject. The system of cover crops as advocated in the East will not apply for various reasons. We can not plant in the fall and expect to get much growth to plow under in the spring because of the short seasons. Then it might not be advisable to irrigate at the particular time the seed should be sown as would probably need to be done to insure the germination of the seed. We have also found that fall plowing is better suited to our conditions than spring, particularly if a crop or manure is to be turned under. If a mass of vegetable matter is plowed under in the spring the ground is apt to remain so porous that difficulty

is experienced in irrigating. The ground at the upper end of the row soon becomes saturated but still a large head of water must be used in order to force it through to the lower end. Naturally the trees at the upper end are injured. Finally, we believe that both land and trees will be benefited by keeping the surface of the soil shaded during the heat of the summer for the reasons already advanced.

In the light of our present knowledge it will probably be the best plan to prepare the land fairly early in the spring and sow the seed. Or if experience shows that we need a certain amount of spring cultivation in order to aerate the soil and to promote soil activities the planting may be delayed until June. Whether in the case of a perennial it will be best to let it occupy the land for two seasons, plowing it under the second fall, or not must be determined by experience and individual conditions. It now seems best to plow the land at least every second season. All of the land may be occupied by the crop in old orchards but with younger trees space must be left for irrigation as well as to prevent the possibility of the crop appropriating food and moisture to the detriment of the trees. There would also be more danger of injury from small vermin and grasshoppers; the latter pest would probably have to be reckoned with in the young orchard at any event.

One must take pains to see that the irrigating furrows are kept open and not allow them to become choked with vegetation. Provision must be made so that water may be as judiciously distributed as though the land were bare. The trees should always receive first consideration; do not allow the prospects of a few jags of hay to warp judgment when it comes to a question of the health of the trees.

Whether or not it will be advisable to remove any of the crop for hay must be determined for each orchard. When the land has been badly impoverished, or is in poor physical condition, all of the growth should be returned to the soil.

If, later on it is found that the continued use of legumes is furnishing too much nitrogen, as will be indicated by a rank growth, then a change should be made; rye or buckwheat may be used instead.

The kind of crop which will be best adapted for use as a shade crop is yet to be determined and it is likely that different soils and different localities will demand different things. Red clover is at present most in favor among the few who have tried any crop at all. A number of orchards at Paonia have recently been planted to clover and the results are very satisfactory. It has made a splendid growth, even close to the trunks of the largest trees. (See Plate I.) Clover also does fairly well in the northern district. Winter vetch has been used to some extent, for several years in the vicinity of Rocky Ford. This plant will make a fairly good growth in any of the orchard districts of the state. A few orchardists are experimenting with Canada field peas. Peas have the advantage that they make a splendid feed if one wishes to combine hog feeding with orcharding. The pods will not fill nearly so well, however as they do in the higher altitudes where the climate is much cooler. Pea seed should, therefore be planted as early in the season as possible. Cow peas have been tried

to a limited extent but the season seems to be rather short for them and the young plants are easily injured by over watering. In one orchard where we were experimenting with this crop the plants made almost no growth, possibly because the proper bacteria were not present. Alfalfa has been tried by some, but at the mere mention of the word most orchardists will hold up their hands in horror. If it were not so difficult to plow it would certainly be an ideal crop for the purpose. We do not wish to give the impression that we advocate the use of alfalfa but is it not possible that a method of handling may be devised that will make its use possible, except in stony land? Why not plant it in rows? then cultivation could be carried on throughout the season if desired. Then if the tops are mown off before the seed has set there ought not to be a great deal of trouble with its spreading. If the turning plow is used when the plants are not over two years old it is not such a difficult matter to cut the roots and the ground will usually need to be plowed that often at least. But if one wishes to continue to grow alfalfa in the orchard it would be an advantage not to kill it out but to have it contiue to come up year after year. Mr. B. A. Smith, of Grand Junction, has been experimenting with alfalfa in one of the best orchards in the Grand Valley and he is very much pleased with the results so far. He does not plan to kill the plants but expects to use the plow and the disc as much as the land seems to require.

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CABBAGE GROWING

BY

E. R. BENNETT

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CABBAGE GROWING ON THE IRRIGATED LANDS OF COLORADO

By E. R. BENNETT

As the irrigated tracts of land in Colorado have become more thickly settled the price of land has risen. With this the character of the crops grown has changed from the extensive to the intensive. That is, where a few years ago farmers depended on wheat, oats, and hay as their money-making corps they have found that at the present valuation of land in many places these crops do not pay a satisfactory interest. This condition has forced the extensive crops to a great extent to give place to such crops as sugar beets, potatoes, cabbage, and onions.

The culture of these crops under irrigated conditions is a somewhat different problem from that of the unirrigated country, so that new comers may save considerable trouble and expense by following the system which has been worked out and found to give the best satisfaction here.

HISTORY OF THE INDUSTRY.

Cabbages have been grown for home consumption since the early settlement of the country. About 1880 the potato buyers of the Greeley district found there was a considerable demand for cabbage in the southern markets and that they could be shipped satisfactorily in the same cars with potatoes. From that time the industry has gradually grown till the output is now from five hundred to one thousand cars per year. Greeley is near the center of the industry, though more or less acreage is devoted to the crop throughout the northern Colorado districts. So far comparatively few have been grown in the mountain districts of the State, because of the lack of transportation facilities in the high mountain valleys.

SOIL.

The soil best adapted to the growth of the cabbage is a cool, moist loam. An abundant supply of available nitrogen tends to promote leaf growth at the expense of fruit or seed. As the edible portion of cabbage, lettuce, etc,, is the leaf rather than the seed, an excess of this element in the soil is beneficial. For this reason the bottom land or peaty lands are generally considered best for cabbage. Nearly any of the soils of this State, however, will grow cabbage successfully if sufficient decaying vegetable matter and manure are added to put them in good condition and to provide the necessary fertility.

CLIMATE.

None of the horticultural products have a wider range as to climate than the cabbage. This vegetable is grown more or less successfully from the semi-tropics to the arctic circle in Alaska. When grown in the South it must be planted so as to mature before the extreme heat of summer. This is also true to a less degree in the northern states and in Colorado, except in the higher altitudes of the mountain valleys. The most favorable climate is found in this State at the altitudes between six and nine thousand feet where the nights are always cool and the days not extremely warm.

PREPARATION OF THE LAND.

Much of the land used for cabbage growing is considered too valuable to rotate in the usual way. If alfalfa sod is used the land may be sufficiently fertile to produce a crop without the addition of manure. In most cases, however, cabbage follow cabbage on the same soil for several years. One successful grower at Greeley has produced a crop of cabbages on the same land fourteen years in succession. In cases of this kind manure is added to the soil at the rate of twenty tons per acre every two years, or ten tons per acre each year.

After the crop is taken off in the fall, the plow is run under each row, turning the old stumps and leaves of the cabbage under. This leaves the surface rough, so as to catch the snows of winter, and exposes more of the soil to the action of the frost. If manure is to be applied it is generally spread on this land during the winter. In the spring before the soil becomes too hard and dry the harrow is run over the tract lengthwise of the furrows, which smooths the surface down to its original level. Following this the ground is plowed to a depth of from eight to twelve inches.

SEEDING.

Seed must be sown from six to seven weeks before it is desired to set the plants in the field. The time of setting early plants ncessarily varies

somewhat with the season. For early cabbage the first seed are sown from March 1st to 15th. At least two sowings should be made to avoid danger of accidents and a possibility of the first plants becoming too large before the weather will permit setting.

Seed for early cabbage are sown either in flats in a forcing house or in hotbeds. If sown in flats, the seedlings soon begin to crowd and are pricked out of the seed flats as soon as the first leaf appears. In this operation the plants may be put into other flats one inch apart each way, or they may be put into hotbeds or coldframes. If the seed are sown in hotbeds the seedlings are not generally transplanted at all till time to set in the field. In this case the seed must be sown more sparingly or the young seedlings must be thinned so as not to crowd. Young plants either in the forcing house or hotbed are apt to be tender and are very susceptible to a disease known as the "damping-off fungus." This trouble is the result of a too high temperature, not enough fresh air, or too much water. The disease is hard to control after it once gets a foot-hold, but may be checked to some extent by remedying these conditions and sprinkling dry sand among the plants. When plants are grown in the forcing house or hotbed, great care must be exercised to properly harden them off before setting in the open ground. In the forcing house this is done by keeping the temperature low and giving all the ventilation possible when the weather will permit. If the hotbed is used, the sash may be first partly removed and later taken off during pleasant weather. Properly hardened plants will endure temperatures of from ten to twenty degrees below freezing point after setting in the field. If not properly hardened off, exposure to freezing temperatures often prove fatal.

For late planting the seed is usually sown in the open ground. If large fields are to be planted, two, three, or even four sowings are made. The first seeding is made about the tenth of April with the others following at intervals of about seven days.

The seed in the open ground is sown in a double row system. That is, two rows are sown from ten to sixteen inches apart with space enough between to run a cultivator and a ditch for irrigation, Since the cucumber flea beetle has caused so much damage to the young plants, some growers are growing the plants for late setting in coldframes. In this case the seed are sown is rows in the frames six inches apart and are allowed to grow in this way until setting in the field. These frames are found to be most convenient if made twelve feet long by six feet wide, or in a multiple of those proportions. The frames are made of boards or planks twelve or fourteen inches high on the back or north side, and lower in front. The covers used for this purpose are made of cheap unbleached muslin stretched on three by six-foot frames. By keeping these covers on the beds during the time the plants are pricking through the ground, the beetles are prevented from getting to the plants. A coldframe of the size mentioned will produce enough plants for about one acre of land.

In planning for the crop it is estimated that one pound of seed will produce plants for four or five acres of land, or fifty thousand plants. This, of course, varies with the germinating power of the seed and weather conditions during seeding time.

PLANTING.

The operation of setting the plants differs more from setting in the humid districts than does other operations connected with the industry. In the East, plants may be set even in fairly dry soil without watering, and few, if any, of these plants sustain permanent injury. The intense sunshine and rapid evaporation of moisture in Colorado are such as to make this method impracticable here.

Setting the plants for the late crop is done sometime during the month of June. After the land has been put in a good state of tilth by the use of the harrow, ditches are made with a shovel plow. These ditches or rows are made in the direction which will make irrigation the most advantageous. The distance between ditches differs somewhat with the variety of cabbage to be grown, and varies from twenty-four to thirty-six inches. The majority of growers plant late cabbage in rows twenty-eight inches apart. These ditches are eighteen to twenty inches wide at top and from six to nine inches deep. After the ditches are made, one man goes along the row dropping plants. These are placed from fifteen to eighteen inches apart in the ditch. Another man follows the dropper to set the plants. In this operation the finger or a sharpened stick is used to make a hole in the side of the ditch about half way from the top to the bottom. The plant is placed in this hole, then the soil pushed back around the roots. Water is

allowed to run in a small stream as closely as possible behind the man who is setting the plants. Working in this way, two persons can set from eight to fifteen thousand plants per day.

From four to eight days after the plants have been set, the water is run through the rows, and sometimes this is repeated two or three times before the ditches are filled. When the plants have become sufficiently established the land is leveled. This is done sometimes by hand with a garden rake, but can be done as well and at less cost with a horse and garden cultivator of the Planet Junior twelve-tooth or Iron Age type. Several

1. Cold Frames
2. Filling in Furrows after Plants have become established
3. Harvesting
4. A Cabbage Field

shallow cultivations are given during the season, and it is usually necessary to go over the field once or twice with the hoe to cut the weeds from the rows.

After the first ditches are filled and irrigation becomes necessary, the shovel plow is run between the rows, making a ditch sufficiently deep to run water across the field without flooding the plants.

IRRIGATION.

Few crops are more particular about water than the cabbage. Although it is a gross feeder, it will soon wilt and stop growing if the soil is dry, and on the other hand, if the land becomes water-logged the plants will turn yellow and stop growth. The frequency and number of irrigations then depends on the character of the soil and the amount of rainfall. If

soils are light and gravelly, with good under drainage, the irrigations must be frequent, and there is little danger of over-watering.

HARVESTING.

The harvesting of cabbage is a very simple operation, as the markets reached are not exacting.

The wagon is driven into the field, the heads cut with a knife, so as to leave just enough of the green leaves to cover the white tissue of the head, then thrown onto the wagon. Not all the heads will be ready for market at the same time, so the fields have to be gone over two or three times before all the crop is taken off.

If the crop is to be shipped, the cabbages are hauled direct to the cars. After being weighed the cabbages are either crated, sacked, or sometimes loaded onto the cars loose.

INSECT PESTS AND DISEASES

Comparatively few insects and diseases have so far troubled the cabbage in this State.

FLEA BEETLE.

One of the most serious insect pests up to the present time is the little black flea beetle (Epitrix cucumeris). These insects feed on the stems and cotyledons of the plants just as the seedlings break through the ground. If the insects are plentiful they sometimes destroy all the plants. Growers frequently fail to locate the trouble because of the small size of the insects and their habit of jumping away from the plants when disturbed. This pest is particularly troublesome if the soil forms a crust so that the insects can find protection under the crust as the seedling comes up.

Several remedies, such as ashes, ground tobacco stems, lime and insect powder have been used with varying degrees of success. If the insects are numerous, the only method of preventing the trouble is to grow the plants in coldframes where the insects can be shut out till the plants are large and tough enough to resist the attacks.

CABBAGE APHIS.

This aphis, commonly called the cabbage louse, occasionally causes serious loss. The attacks usually occur after the plants are partly grown. The lice suck the juices from the leaves and cause the leaves to curl. After this curling occurs it is difficult to get at the insects to kill them. The multiplication of these insects is so rapid that the infestation soon spreads and becomes a serious menace to the crop if not checked.

REMEDIES.

Ordinarily this pest is held in control by parasites. When the parasites do not prevent the multiplication of the lice they can be held down by spraying the infested plants with some contact poison as tobacco decoction or kerosene emulsion.

CABBAGE WORM.

The common green cabbage worms that eat the leaves of the cabbage and cauliflower are the larvae of the small yellow, white or spotted butterflies that may be seen flying over the plants during the growing season. The larvae of these butterflies are so nearly alike in appearance and habits that they are hard to distinguish and may all be treated in the same way.

Little or no attention is paid to them in the larger fields, as they seldom become numerous enough there to cause serious damage. The only effectual remedy is to dust on some form of arsenical poison, as Paris green, before the plants are too much matured. There is comparatively little danger in using these remedies on cabbage, as the head is formed from the center, so that what little poison adheres to the plant will be on the old outside leaves rather than in the edible portion of the head.

CUT WORMS.

These insects, too, are the larvae of several different species of moths. Most of these lay the eggs on plants in August or September. The larvae hatch and become partly grown during the fall, then hibernate in the soil till spring, when they are ready to eat the young plants when set. The late crop is not apt to be troubled with these insects, for at the time the plants are set the larvae have become developed, stopped eating, and have gone into the pupal stage.

Probably the best remedy is shallow, late fall plowing. This exposes

the half-grown worms to the frequent freezing and thawing and kills off the larger part of them.

THE HARLEQUIN CABBAGE BUG.

This insect is a true bug, similar to the squash bug, and feeds by sucking the juices. Where this insect is prevalent it is a serious menace to the industry because of the difficulty of combating it. The remedy is to spray with a contact poison, but the insect is difficult to combat, because of its habit of hiding among the leaves. So far the pest has not become general over the State, but has been found in a few places.

CABBAGE MAGGOT.

So far this insect, which is a serious menace to the industry in some parts of the East, has not been reported in this State. The maggot is the larvae of a small fly. The adult lays the eggs on the young plant, near the surface of the ground, and the maggots feed in the stem of the plant under ground and destroy the plant.

FUNGOUS AND BACTERIAL DISEASES

The cabbage in Colorado seems to be almost immune to fungus diseases.

Black rot of cabbage occurs intermittently. Some years the crop has been seriously affected with this disease and, the year following, the same land in cabbage did not show any signs of the disease.

CLUB FOOT.

This dreaded eastern cabbage disease is hardly known in the State. Turnips have occasionally been found affected by the fungus, so that it is probably that, because of some peculiarity of Colorado soils, such as the alkalinity, the fungus does not thrive here.

COST OF GROWING AND AVERAGE PRICE OF CROP.

The cost of growing crops necessarily depends upon the character of the soil, condition of the land, distance from market, etc., so that an exact estimate is hard to make.

The following figures are estimated on the basis of the cost of growing and marketing potatoes and sugar beets as given by the Greeley Commercial Club:

Fertilizer (10 tons per acre)	$ 5.00
Plowing	2.50
Leveling and harrowing	1.00
Seed	.50
Growing plants	1.80
Setting plants	6.00
Cultivation and ditching	2.50
Hoeing	2.00
Irrigating	1.50
Cutting and hauling	10.00
	$32.80

This cost is two dollars and twenty cents less than for potatoes, and twelve dollars and twenty cents less than for sugar beets.

Like all perishable truck crops, the price of cabbages varies inversely with the size of the crop. By far the larger part of the crop is shipped out of the State, so that local consumption makes no difference with the price. Neither does the size of the crop in the State seem to make any material difference in the price, because other competing cabbage-growing districts produce the larger part of the total output.

The following table, taken from the books of one of the potato and cabbage buyers at Greeley, shows the price paid the growers each year for a consecutive period of ten years:

Year 1899	$ .40 per hundred
Year 1900	.50 per hundred
Year 1901	.75 per hundred
Year 1902	.25 per hundred
Year 1903	.40 per hundred
Year 1904	.25 per hundred
Year 1905	.50 per hundred
Year 1906	.25 per hundred
Year 1907	.50 per hundred
Year 1908	.75 per hundred

This makes an average price for ten years of 45.5 cents per hundred pounds. The average yield per acre for the State is difficult to obtain. Theoretically, with from twelve to fifteen thousand plants to the acre, there should be a yield of five pounds per head, or from fifty to seventy-five thousand pounds per acre. In practice, only from fifty to seventy-five per cent. of the plants ever make heads. As many pounds per acre could be obtained by placing the plants much farther apart. Large heads, however, are undesirable for shipping, so the size per head is cut down by thick planting. The actual yield per acre is from fifteen to fifty thousand pounds.

The minimum yield at the average price makes a gross return of about seventy-five dollars per acre and a net return of something over forty dollars. This year some fields near Greeley have brought a gross return of $355.25 per acre.

MARKETS AND STORING.

When the market will permit, the crop is sold direct from the field. Some seasons, however, the market at harvest time is over supplied, so that storing becomes necessary. Several methods of storing are used in various parts of the country. In any case, cabbage for storing should be left in the field as long as possible before harvesting. The heads should be dry and not frozen when handled. Undeveloped heads may be stored in trenches, the roots buried in soil and the tops covered with straw or manure as for seed. In this way many of them will make marketable heads in January or February that were soft in the fall. Mature cabbage may be cut as for market and stored in bins in the potato or onion dugouts, providing plenty of air circulation all around the cabbage is given and the temperature is kept close to the freezing point.

VARIETIES.

It has been found that cabbage, like potatoes, are more satisfactory for market if only a few well-known varieties are grown in a community. At Greeley, Winningstadt, Hollander, and Cross are grown almost exclusively.

The two former varieties are too well known to warrant a description. The true name of the latter is "Ne Plus Ultra," but is much better known as "the Cross" cabbage. This cabbage is the result of an accidental cross made in 1894 between the Winningstadt and Henderson's Excelsior Flat Dutch. These two cabbages are radically different in type, the former being decidedly conical in form and early, while the latter is late and decidedly flat in form. The Cross is as nearly as possible half way between the two parents in season and form, being medium early and nearly globular.

The originator, Mr. John Leavy, of Greeley, says: "To the growers it needs no recommendation, as they willingly paid $10 per pound for the seed. * * * * Its advantages over all the so-called standard varieties are as follows: Fine texture, more solid and compact, crispness, and a heavier yielder than any variety grown at Greeley." Though this cabbage has been grown from select seed heads since 1895, there is still a tendency to revert to one or the other of the parents. Each year, while the majority of the heads in the field will be globe-shaped, there are many that are conical or flat. This variety has never been listed on the market, except locally at Greeley and Fort Lupton, for notwithstanding the price of seed has been two or three times as high as other varieties, there has never been more than enough seed to supply the local demand.

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CELERY GROWING IN COLORADO

BY

L. J. REID

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CELERY GROWING IN COLORADO

By L. J. REID

Climatic conditions in Colorado have made irrigation a necessity and, as a result, we find that the growing of certain crops has been very much specialized. Thus, celery growing has become an important industry in those sections where conditions are such as to make it most profitable. Celery delights in our cool nights and its crispness is improved thereby.

It is only in the last century that celery has become an important article of human diet. The wild celery, a native of the swamps and lowlands of England and Europe, is a small, tough plant of bitter taste. This has been improved by selection and better culture methods until today it is much used on our tables. Since the draining of the muck beds of the Great Lakes, commercial growing has made rapid progress until certain sections have become famous as a result of the extensive raising of this vegetable.

In the vicinity of the largest cities of the state a very intensive system of gardening is carried on. Under these conditions, from two to ten acres are all one man can care for, and even then help must be employed at many times. Those who grow celery in the field during the summer generally grow lettuce, radishes and cucumbers in hotbeds and coldframes during the colder seasons. Some of these beds are used in the spring for the raising of the celery plants.

Soils.—Since celery is a native of moist land, it is natural to suppose that it should be grown on muck soil, and it is true that the largest crops are generally grown in this way. However, it is well known that celery grown on mucky soil is not of as good quality as that grown on firmer ground. Celery growing in Colorado is mostly confined to the river bottom lands, for the reason that these have more sand than is usually found in the uplands; they contain more vegetable matter; are less liable to excessive drying out; and usually the water supply for irrigation is more certain. The ideal celery soil is a rich, loose sandy loam. Owing to our dry climate it has come about naturally that celery growing is confined mostly to those low lying lands where the water is close to the surface, and on soils which never become very dry. Alkali in small quantities does no harm. In fact, some of the best celery land is white with alkali during the winter.

Preparation of the Land.—Since the farms are small, there has been very little crop rotation, but instead heavy manuring has been practiced. A cheap supply of manure is always available in the vicinity of large cities, where the celery gardens are usually located. As a rule, this may be obtained for the hauling, any kind of manure being used, but care must be taken not to apply that which

contains much straw or rubbish, as it interferes with cultivation and irrigation. The grower usually hauls as much manure as he has time to, thus sometimes applying as much as fifteen or twenty loads to the acre. This is the practice of those growing Self-blanching on the heavier bottom lands. The Pascal growers do not manure so heavily, claiming that if they did their upland soils would become too light. However, they often use a few hundred pounds per acre of commercial fertilizer, mostly composed of slaughter house refuse. This is drilled in beside the row during the growing season. A garden drill with an extra large hopper is used for distributing the fertilizer.

The ground is plowed six or eight inches deep and worked into good garden shape before setting the plants. Some practice plowing about twelve inches deep every third year.

VARIETIES.—In commercial growing only two varieties are being used at the present time to any great extent. These are the Golden Self-blanching for the early market, and Giant Pascal for the late market. These supply all that the present market requires, for by proper methods, Golden Self-blanching can be put on the market from early August until the Giant Pascal is ready and this latter can be held as long as it is profitable to keep it in storage. The Golden Self-blanching is not as crisp and tender nor of as good quality as the Giant Pascal, but owing to its earliness, the ease with which it is blanched and the fact that so much more can be grown to an acre, it is far the more important in respect to the amount grown. Pascal celery does not come onto the market until about the first of November and we are entirely dependent on the Self-blanching up to that time.

SEED.—Most of the seed is procured from American dealers, but the growers nearly always ask for French grown seed, because in that country the seed is usually more carefully selected. A few growers have sometimes grown their own seed and obtained excellent results by its use. Sometimes a grower will raise enough seed one year to last him several seasons, preferring to do this rather than use seed bought from unknown sources. So far as the writer knows, there is no one in this section growing his own seed each year. The reason given is not because good seed cannot be grown here, but because the price of seed is so low that it is unprofitable to grow it for sale, and the growers will not go to the bother of keeping plants over winter just for their own seed. Owing to failures as the result of poor seed, it seems as though the use of home grown seed would be more than justified, even though it cost more.

Vitality of seed is quite variable, so it is impossible to figure the number of plants which may be procured from a given amount. It is estimated in buying seed that one can count on 2,500 plants per ounce of seed, but this is very conservative, for some growers

1. Spent hotbeds in which Golden Self-blanching plants are grown.
2. Double rows of Golden Self-blanching, July 3d.
3. Blanching double rows by means of boards. Owing to the field being very level it was necessary to irrigate in the wide spaces between the rows the last time. It is best to always irrigate in the narrow spaces,

get as high as 25,000 stocky plants per ounce when they have good seed. The number of plants suitable for planting depends upon the vitality of the seed and the care of the grower. It is the practice to sow enough seed to secure more plants than will be needed and then select the best of these. Very often a surplus stock can be sold at a good profit, and it is also advisable to have extra plants for resetting in case of damage to young plants by drought or hail-storm.

RAISING THE PLANTS.—Celery seed is very slow in germinating and sometimes great difficulty is experienced in getting a good stand of plants. Here is where the gardener must ever be on the alert. The seed bed and young plants must never be allowed to become dried out, and yet water must not be allowed to stand on the surface. The young plants are very tender, and a fine spray should be used in watering them. The seed is sown broadcast in the beds or sometimes in very shallow drills four or six inches apart. The seed should be covered very lightly, if at all. Germination will take place in about three weeks.

The Golden Self-blanching celery is usually sown between March 1st and 15th in mild hotbeds from which have been taken one or two crops of radishes or lettuce. These beds are made with about one foot of manure, over which is spread between six and twelve inches of soil, and the whole is covered with glass sash. By the time one or two crops of lettuce have been taken from a bed, the manure does not give a strong heat, but just enough to protect on frosty nights. If one desires this celery for the August market, it is quite necessary that some artificial heat of this sort be given the seed bed, but fresh beds should be used only with great care or the plants will not be strong. For later sowing of the seed, frames simply covered with sash may be used.

The Pascal celery is mostly sown between April 1st and 15th in frames under cloth, although a great deal is sown in the open ground. The advantages of growing under cloth are that the soil is kept from drying out and the young plants are protected from extremes of temperature. It is not considered profitable to transplant celery, so it is left in the original beds until ready for setting in the field, although much more stocky plants may be secured by giving an extra shift.

When the plants are grown in hotbeds, as many as eight thousand are sometimes raised under a three by six-foot sash. However, when less expensive beds are used, it is better to use more room, as one thus gets far stockier plants. Many growers sow one-fourth ounce of seed to one sash three by six feet, but this crowds the plants somewhat. It is very important that the plants be carefully "hardened off." This is done by gradually getting them accustomed to the wind and sun. The sash is raised more and more each pleasant day until the plants can stand to be entirely uncovered. It is very

important that they should never be allowed to become cold enough to be frosted, as this no doubt is one of the principal causes of going to seed.

Several methods are in use for making the plants stocky. Transplanting has already been mentioned, but this is an expensive process. Clipping the tops off lightly once or twice while in the beds is practiced to quite an extent. A few growers have a knife so mounted on wheels that it can be run under the plants, so as to cut off the tap root, thus causing more side roots to develop.

SETTING OF PLANTS IN THE FIELD.—When the ground has been thoroughly prepared and danger of frost is over, the plants may be set in the field. If an early crop is desired it is, of course, necessary that the plants be set early, so as to give them as much time as possible to get their full growth. If the plants are crowded in the seed bed, it is a good practice to thin them and use the plants removed for the first setting. This gives the remaining plants a better chance.

A small furrow is made and the irrigating water is turned into it. This settles the soil and puts it in good condition for setting the plants. After the water has seeped out of the ditch it is the plan of most growers to run a small stream into the furrow again. The surface of the water this second time leaves a line along the edge of the furrow and the plants are set along this line, thus making them all at the same level. In this way none of the young plants are covered when irrigated, and yet all are close to the water. Where Self-blanching is grown, a row is set on each side of the furrow, making two rows about twelve inches apart. Where Giant Pascal is raised, plants are set only on one side of the furrow, and that on the south side if the furrows run east and west, so that the plants may escape the reflection of the sun's rays from the water. The furrows are made about four feet apart. The plants are set from six to eight inches apart in the row. With single rows four feet apart, plants eight inches apart in the row, 16,710 plants would be required per acre; with plants six inches apart in the row, 21,780 plants would be used per acre. When Self-blanching is grown in double rows, just double this number of plants would be used. It is well to have an abundance of plants so that later on any vacant places may be filled.

The beds are watered very thoroughly before removing the plants for setting, and then the plants may be pulled out singly by the roots if it is desired to thin the beds somewhat. The plants are arranged in bunches which can be held conveniently in the left hand. They are put in a box over which is thrown a wet sack to protect from the sun while being carried to the field. In setting, some simply lay a plant on the first finger of the right hand and stick it into the mud on the side of the furrow; others, where the soil

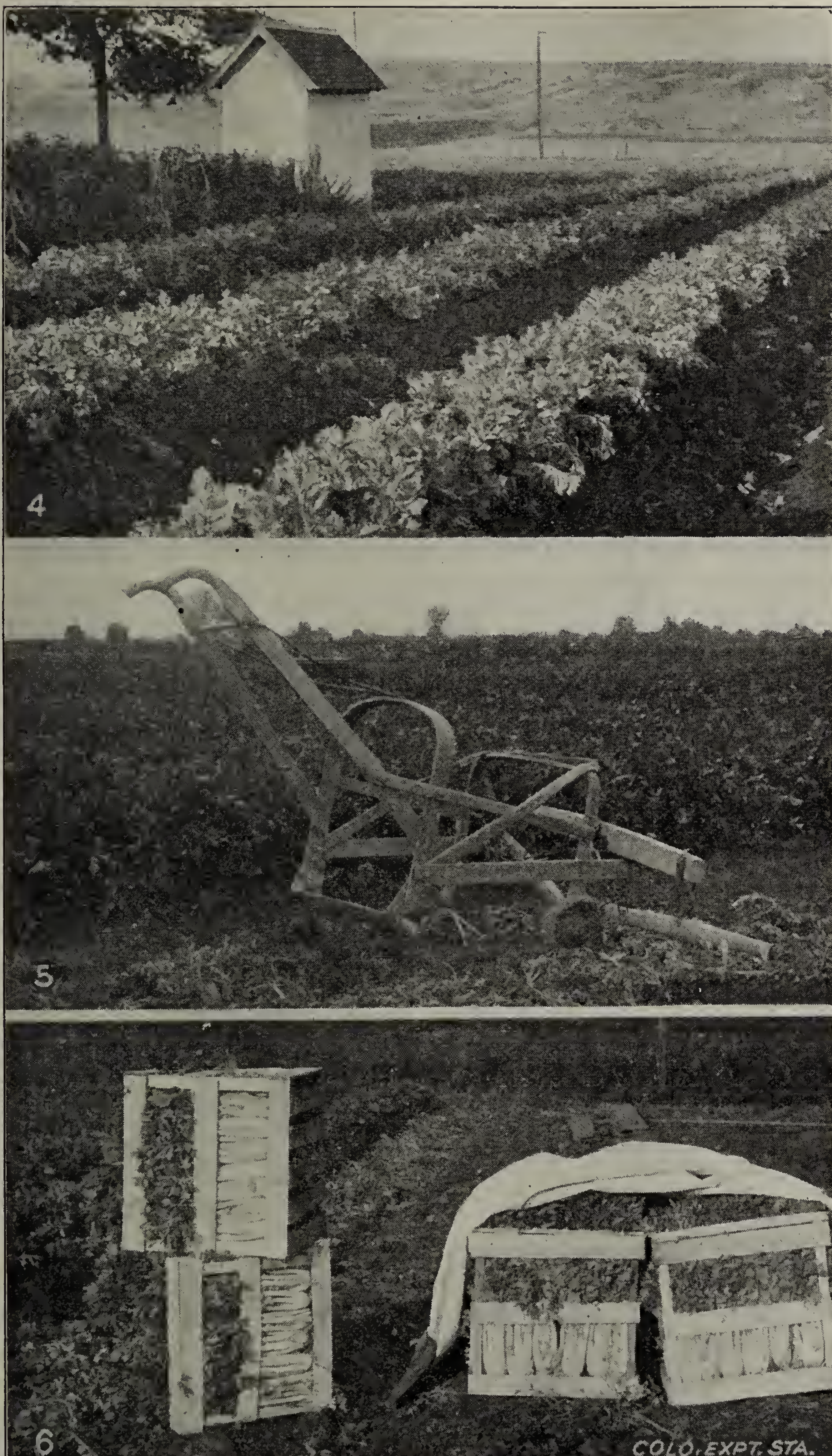
is heavier, make a hole in the soil with a pointed dibble held in the right hand and place a plant in the hole with the left, the dibble then being stuck into the soil beside the plant to close the hole. It is a good plan to wet the roots with puddled mud just before starting to set a handful. There is quite a knack and a whole lot of hard work in setting, but it can be learned much more quickly by watching a good workman and by doing it oneself than by reading how to do it.

CULTIVATION.—Since celery is transplanted to fields which are clean of weeds, the plants have the start of the weeds. However, it is generally necessary to give one or two hand weedings. A wheel hoe is used once or twice, and four or more cultivations are given with the horse and a harrow-tooth cultivator in the wide spaces. Some make a practice of cultivating once a week during the growing season. Those who blanch with dirt often use a five-tooth cultivator the last time or two, so setting the teeth as to throw some dirt toward the rows.

IRRIGATION.—Concerning irrigation each grower has his own ideas as the result of his experience under his particular conditions. Some do not irrigate more than two or three times during the season. Others irrigate nearly every week, commencing at the time of setting. On sandy, well-drained soils it is necessary to irrigate very often. One must use his own judgment, always remembering that celery grows in swamps in its natural condition and, therefore, cannot stand drought.

During the growing season the water is run in the furrows which were made at the time of setting the plants. If double rows are used, as soon as the crop has a good start this furrow will be completely hid by the tops of the plants, but the water will still follow the ditches in good shape if they have been kept clean of weeds. Since the ditch at this time is shaded by the plants, the soil dries out less rapidly and does not bake so badly.

BLANCHING.—Blanching consists in so excluding the light that tender stalks free from coloring matter may be obtained. Self-blanching varieties for the early market are blanched entirely with boards. The banking of celery high with earth during the hot summer days sometimes hurts the crop. Blanching with boards keeps the celery cleaner, but is quite expensive, owing to the great cost of lumber, so it is generally practiced only for a part of the early crop. Boards twelve or fourteen inches wide by any convenient length, usually sixteen feet, are used. It takes about twenty thousand feet of lumber to blanch an acre at one time, but since during the warm part of the year the blanching will be completed in about three weeks, the boards may be used to blanch a second lot. If the boards are carefully piled each year so they will not warp and



4. Blanching by means of earth.
5. A double row digger made by a local blacksmith
6. Crates of Golden Self-blanching ready for shipment.

are protected from the weather in some way, they will last many years. The manner of their use may be seen in one of the illustrations. Some use wire hooks to hold the boards together instead of using stakes.

By far the largest part of the crop each year is blanched by means of earth. One horse is used on a celery hiller, which runs between the rows and throws the dirt against the plants. It is generally necessary to run this machine through twice in order to do a good job, and some times two horses must be used tandem to pull the hiller. Some growers like to finish the earthing with shovels or hand tools, but this adds to the expense. The celery hiller has iron rods so fixed as to lift the leaves out of the way so they will not become covered with earth. About four weeks are necessary for blanching with earth in the field.

For later use a great deal of celery is left to grow in the field as long as there is no danger of frost, and then removed to trenches for blanching. Giant Pascal is either blanched in this way or is partly blanched in the field by means of "papering," and then removed to the trenches. A great deal of self-blanching is also blanched in trenches. The celery is removed from the row, without trimming the roots too closely, and put into long, narrow trenches, so that about two-thirds of the plant will be below the level of the ground. From twelve to eighteen inches is as wide as the trenches should be made, for, if too large quantities are stored together, there is danger of loss from heating. The tops of the plants are covered with light material only as there is danger of freezing. When extreme cold weather comes, earth must be used for protection. Careful watch must be kept to see that the celery does not spoil from being covered too deeply, and yet, if it is allowed to become frozen to any great extent, it will be unsalable. As soon as the plants are set in the trench, water is turned in and a thorough irrigation is given. This will usually furnish enough moisture for the crop until it is ready for the market. If, as is often the case with Giant Pascal, the celery is not dug until late and is to be kept far into the winter, a second or a third irrigation may be necessary in dry seasons.

There is a limited market for "papered" Giant Pascal celery. By this is meant the wrapping of each plant in paper during the latter part of the growing season. This work is commenced in August, and boys are usually hired to do it at two and one-half cents per dozen plants wrapped. Old daily papers are used, and one string holds the paper in place. It is important that this work be postponed until the celery is high enough so that the tops of the leaves will be above the paper after wrapping. Old papers can be bought for eight or ten dollars per ton. As soon as there is danger of frost the celery is dug, put in trenches, and handled in the same

way as the other; but has, however, the advantage of being cleaner and is already partly blanched.

STORING.—Since the California and Florida crops get onto the market during the winter and spring, it has not been found profitable to store celery for any great length of time. In some states large celery storehouses have been used for keeping celery during the winter. In Colorado, there are few weeks during the winter but what it is possible to dig celery from the trenches and get it onto the market. However, considerable is lost in the trenches by freezing and occasionally the weather stays so severe that it is impossible to get the celery out to supply the demand. It is quite probable, therefore, that storehouses will be used to a considerable extent in the near future.

HARVESTING AND MARKETING.—Where only a small area is devoted to celery, the plants are usually loosened from the ground by means of a spade. The roots are cut off and the plant is laid to one side. Where the acreage is larger, especially where soil is used entirely for blanching, a celery digger is used. Different styles of home-made machines are being used for this purpose, but the principle of them all is to run an edged tool just under the plant, thus cutting off the root so it can be taken up by hand. One of these machines for use in loosening a double row is shown in an illustration.

Golden Self-blanching celery is usually "shipped in the rough." A few of the outside leaves are removed and the celery is packed directly into crates, as shown in an illustration. The number of dozen plants in the crate is marked on the outside, the side of the crate is nailed, and the crate is ready for the car. These crates are usually 20x22 inches by 24 inches deep. As can be seen in the illustration, the top is entirely open, except for a strip along each edge. When celery is to be packed for "shipment in the rough," one of the other sides is left open so that the plants may be packed in from the side. The remaining side is then nailed on and the celery is thus held securely in place A crate will hold from four to seven dozen of celery, according to its size at the time of marketing.

Most of the Pascal celery and some of the Self-blanching is carefully trimmed, washed, and tied in bunches of twelve before marketing. In this case the crates are lined with paper before the celery is laid in them. All celery must be washed, bunched, and trimmed before it gets to the retailer, and if this is not done by the grower it must be done by the commission merchant. Some dump the celery into a washing tank and scrub the dirt off by means of hand brushes. Others place the celery in a rack with sides of woven wire, the rack being so pivoted that it can be turned over. A hose is turned on and the dirt washed off. The rack is then turned over and the celery is washed on the other side. Of course, all of the soft outer leaves are pulled off of each plant before washing and the root is trimmed down to a pointed shape. For convenience in bunching, pegs are stuck into holes

in the table or two small boards are fixed so that the celery can be held in a neat bunch of twelve until tied with a string or tape.

Colorado celery is mostly shipped south and east. Texas takes a great many cars, and Kansas City, New Orleans and St. Louis are good markets. During the season of 1908 shipments were made as far east as Pittsburg. The crop is marketed through commission men and through fruit and vegetable associations.

Cost of Growing.—The cost of growing depends on the value of the land, the kind of celery grown, amount grown on an acre, methods of handling and methods of marketing. It can readily be seen that there is more expense in raising forty thousand early plants to the acre than in raising thirty thousand for the late market. It costs more to get the crop ready for the market, because the plants have to be raised under glass and the crop will most likely be blanched with boards. However, the early crop commands a considerable higher price than that which is marketed later.

Some growers claim that $70 per acre will cover cost of manuring, plowing, growing plants, setting, irrigating and harvesting, when shipped in the rough. This does not include rent of land. However, the expense is liable to run considerable higher than this, especially if the crop is blanched with papers, or if it is trenched, washed and bunched before marketing. In the latter case expenses may frequently run over $150 per acre. Of course, if prepared in this way, one should get enough to pay for the extra work. Eastern growers sometimes expend as high as $400 per acre on this crop, largely due to the great cost of commercial fertilizers and manures.

If the grower has good success he should be able to sell his crop for $250 per acre even at the low prices of last season. Some growers, when prices have been extra good, have secured over $1,000 per acre for their crop, but this, of course, is exceptional.

Growing for the Local Markets.—At the present time the growing of celery is confined mostly to the vicinity of the large cities which do not have any local growers, and consequently have to ship in all their celery. Since celery wilts rapidly, it could be furnished in much better condition by local growers who, in this way, would be able to secure the best price. Nearly all our towns have at least some river bottom land well adapted for this crop, the principal requirements being a rich soil retentive of moisture with a steady supply of irrigation water.

Diseases and Difficulties in Growing.—There are no serious insect pests to interfere with celery growing in Colorado at the present time.

There is always more or less complaint of pithiness, but even this does not seem to be a serious trouble under our conditions. Under irrigation the crop may be kept growing evenly and steadily and this probably lessens the per cent. of pithy celery. It is, of course, of great advantage to get seed of the best grade, as pithy celery will much more likely result if a poor quality of seed is used.

The greatest drawbacks in celery growing is the production of "seeders." The plants may appear perfectly normal until along in the summer, when they suddenly send up a seed stalk, thus making the plants valueless. It is not an unheard of thing to have one-half of the crop suddenly go in this way. There are many theories as to the cause of this. Many think it is the result of the plants becoming frosted while in the seed bed or in the early part of the season. There is not much question but what a severe freezing may cause a large part of the plants to go to seed the first season. However, it appears that a severe drying out of the young plants may cause the same difficulty. It is generally agreed that a severe check of any sort may cause this trouble, evidently producing the same result as passing through the winter.

One thing which caused considerable failure during the past season was that so many poor plants were set in the field. If we expect to get good marketable celery we must not use small, dwarfed or stunted plants. Celery growing requires very careful, intelligent work in the spring and proper handling throughout the summer, but it gives good returns to him who knows how and is willing to do his part in assisting nature.

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The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Dry Land Farming In Eastern Colorado.

(Information Bulletin.)

BY

H. M. COTTRELL

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

INTRODUCTION.

This bulletin is intended as an aid to settlers, many of whom have been coming into Eastern Colorado, attracted by the prospect of cheap land and the hope to develop homes. While there have been successes on the plains, our duty would not be performed to the proposed settlers nor to the State without a word of caution. The important thing for the plains is not so much a large settlement as the success of those who do come. It should not be forgotten that there are many chances of failure. This is not entirely due to the country, for many are not able, or do not care, to adapt themselves to the conditions. Experience indicates that the best hope of success is to be found in dairying and in poultry growing, with crops as an important adjunct, grown principally for forage.

It is well that each intending settler should see the plains, learn the difficulties, satisfy himself whether he is adapted to them. I would not discourage such, but those who do not understand the conditions, who are not adapted to them, or who do not have capital enough to tide over one or more unfavorable years are apt to meet with bitter disappointment. Sometimes the impression has been disseminated that some newly discovered practice termed "scientific" has overcome the previous difficulties and lessened the dangers or that there has been a change in climate. This is misleading to say the least. No practice lessens the need that plants have for water though there may be better use of what is to be had.

The principles are those of good cultivation everywhere. Aid should be made of every favorable condition, and then there will be years of hardships. The use of irrigation from wells, by pumping, the collection of floods in draws or gulches, the building of ditches to hold the runoff waters and give time for them to be absorbed, may serve as additional aids of considerable value and help to tide over unfavorable seasons.

For those who meet the conditions with patience and intelligence there may be abundant success.

L. G. CARPENTER, Director.

Dry Land Farming In Eastern Colorado

BY H. M. COTTRELL.

Dry land farming is a continual fight against relentless, unfavorable conditions. Success depends upon the man; his courage, his knowledge and judgment, and his persistence. Physical strength and endurance of both men and women is a large factor in this struggle. With the best seeds and methods of tillage there will be some years of total failure and many others of short crops. It is safest to lay plans that will furnish a living with an average of two failures each five years. There have been three consecutive years of no crops followed by as many years of good crops.

Conditions are much more favorable than they were twenty or even ten years ago. There has been no increase in the rainfall, but the methods of storing and holding moisture in the soil are better understood. Today there are dry land plants that will produce crops with limited rainfall and seeds of these crops that have been selected and bred under arid conditions.

Thousands of failures have occurred on the Plains that have been due to other than climatic causes. Men came and used seeds and methods adapted only to humid regions and persisted in the face of continuous failures until they lost their all. Men came without the capital absolutely necessary to carry them over poor years, and their first seasons were ones of severe drought. Men arrived with families, and after paying the freight on their few household goods had no money left. They had not been thrifty enough to save anything in a humid country, where they had been familiar with profitable methods from childhood. They started in an arid climate, penniless, without any knowledge of the methods needed, and with seed, feed and family supplies to be purchased for from six months to two years before any revenue could be expected. Men came with little money to raise grain exclusively. The surest income in eastern Colorado is made from dairying and poultry.

A man unfamiliar with dry land farming should not settle on the Plains unless he has sufficient capital to erect the buildings that are absolutely necessary, to buy the needed teams and implements, and after making these expenditures, have sufficient money left to pay for seed, feed and living expenses for two years.

Men have taken claims in eastern Colorado who had little or

no money, and after years of pinching and hard work have secured a comfortable home and good living. They have been men of dogged perseverance and good judgment, and usually their families have suffered hardships which no man has a right to ask of his wife and children. Thousands of other men have come with little money; their first years were during drought, and after losing their little, moved eastward, often with the help of friends.

After selecting land and erecting a temporary stable, the new settler should either rent a house or live in a tent until he has secured a good well. In many cases comfortable houses and stables have been built and a good acreage broken, all to be finally abandoned and the investment lost because no water could be secured on the farm.

In some places on the Plains the underground water seems to exist in narrow strips with wide areas on each side without water In other places, the underground water can be secured wherever wells are dug deep enough to tap the sheet water. There is little information that will enable the new settler to form any idea as to what the difficulties in most localities will be in finding water, and as the Plains of eastern Colorado cover an area as great as the State of Ohio, there is a wide variety in conditions. Two neighbors took adjoining claims, and after erecting buildings, breaking ground and putting in crops, hauling all water three miles, started to dig wells. One man put down twelve holes without finding water. The other man found water in his eleventh well, and it was half a mile from his buildings.

After a good well has been secured, permanent buildings may be constructed and land broken and crops planted. The living should be made from dairy cattle and poultry and the methods suggested in this bulletin followed.

The new settler had better break up and seed not over forty acres until he has learned how to farm under dry land conditions, and he should till this thoroughly. Ordinarily, three hundred and twenty acres of dry land will be needed to comfortably support a family. A good arrangement for this is eighty acres in growing crops, eighty acres in summer fallow, or part in summer fallow, and part in crops intensely cultivated, and one hundred and sixty acres in grass. With this amount of land it will often be profitable to rent a winter pasture.

In most dry land counties there are farmers who have lived on their farms for many years, studied local conditions carefully and have comfortable homes with fruit, garden and shade. The new settler should get acquainted with such men at once and should watch and study their operations month by month. The average old settler has not succeeded in making much of a home and usually what he does and says discourages the new neighbor.

The Director of the Colorado Experiment Station, Fort Collins, and the Superintendent of the U. S. Dry Land Experiment Station,

Akron, Colorado, will be glad to furnish any information they or their associates may have and should be consulted often. Reliable books on Dry Land Farming should be thoroughly studied.

Every advantage should be taken of natural conditions. Draws and the lower areas of high uplands can be prepared for garden, fruit trees or alfalfa. Often many acres can be watered from higher prairie lands by running furrows through the sod to catch the storm water as it runs off. It is well to look for such opportunities when selecting a farm. It takes several years to get prairie sod in good condition, but with thorough tillage the tilth and the water-holding capacity increase each year.

THE SYSTEM OF FARMING TO FOLLOW.

Exclusive grain growing in dry land farming has been a failure wherever tried during the past thirty years in Kansas, Nebraska, Minnesota, the Dakotas and Colorado. Yet most of the settlers on the dry lands of eastern Colorado, in the past three years, came with the idea of growing grain only. Many have boasted that they did not even keep a cow for milk.

Hundreds of these grain growers have failed, lost their homesteads and what money they brought with them, and have had to leave the state, sometimes with the help of eastern friends. They made the inevitable failure which was certain to come from their disregard of the experiences of tens of thousands of farmers who had worked under similar conditions. This makes the third time that eastern Colorado has been settled and then almost depopulated.

To many new settlers who are starting in dry land farming on the plains of eastern Colorado, dairying and poultry raising offer a sure income. In the past thirty-four years there have been but few years so dry but that a sufficient quantity of feed could have been raised together with the native grasses to produce a good yield of milk.

Dairying and poultry raising are the profitable lines to follow in dry land farming where the settler's capital is limited, as both give quick and regular cash incomes.

The average annual rainfall on the Colorado Plains varies in different localities from 13 to 19 inches, adequate with good methods, to produce a profitable crop of wheat. In about half the years the rainfall is below these averages, and has dropped as low as 6.93 inches in 12 months, in one section, and in other places to as low as 7.11 to 10.74 inches.

In years of low rainfall, the moisture is not sufficient to produce crops of grain, but there is usually enough for fair yields of forage crops, such as milo maize, sorghum, kafir corn, corn fodder and hay from wheat, oats and barley. These forage crops are not marketable, but become money makers when fed to dairy cows and hens.

Dairy cows and hens, properly selected and handled, will furnish

a comfortable income and enable the farmer to pay cash for his family purchases, no matter how dry the year. Then, the dry land farmer should seed as much land to wheat as he is able to prepare thoroughly with intensive cultivation, and when he raises a crop, the money from it will be surplus cash and will not be needed to pay old store bills, as is the case with the strictly grain farmer.

DAIRYING.

The income in different dairy herds of Colorado ranges from $12 to $120 per cow per year, depending upon the quality of the cows kept and the way they are treated. Careful farmers in the dry land section should make good cows give an average return of $30 to $50 each per year. Many do not get more than $12 per year per cow.

The dry land farmer's supply of feed is constantly limited by the sparse rainfall, and for this reason he needs the dairy cow that will make the most from every pound of feed that he can give her. The selection of the cow is of first concern.

The largest returns in Colorado are being secured from cows of the extreme dairy type and of the Holstein, Jersey, Guernsey and milking Short horn breeds. The unprofitable dairy cows are those that convert most of their feed into flesh and yield a good quantity of milk for a few months only.

Most dry land farmers do not have the money with which to buy pure bred dairy cows, and can not give them the necessary care, shelter and feed. Generally the dry land farmer had better secure his cows from neighboring herds of beef cattle, selecting the cows with dairy forms that are usually found in beef herds. Not always, but as a rule, he will find that such cows are grade short horns.

In selecting range cows for dairy herds there are four essential points:

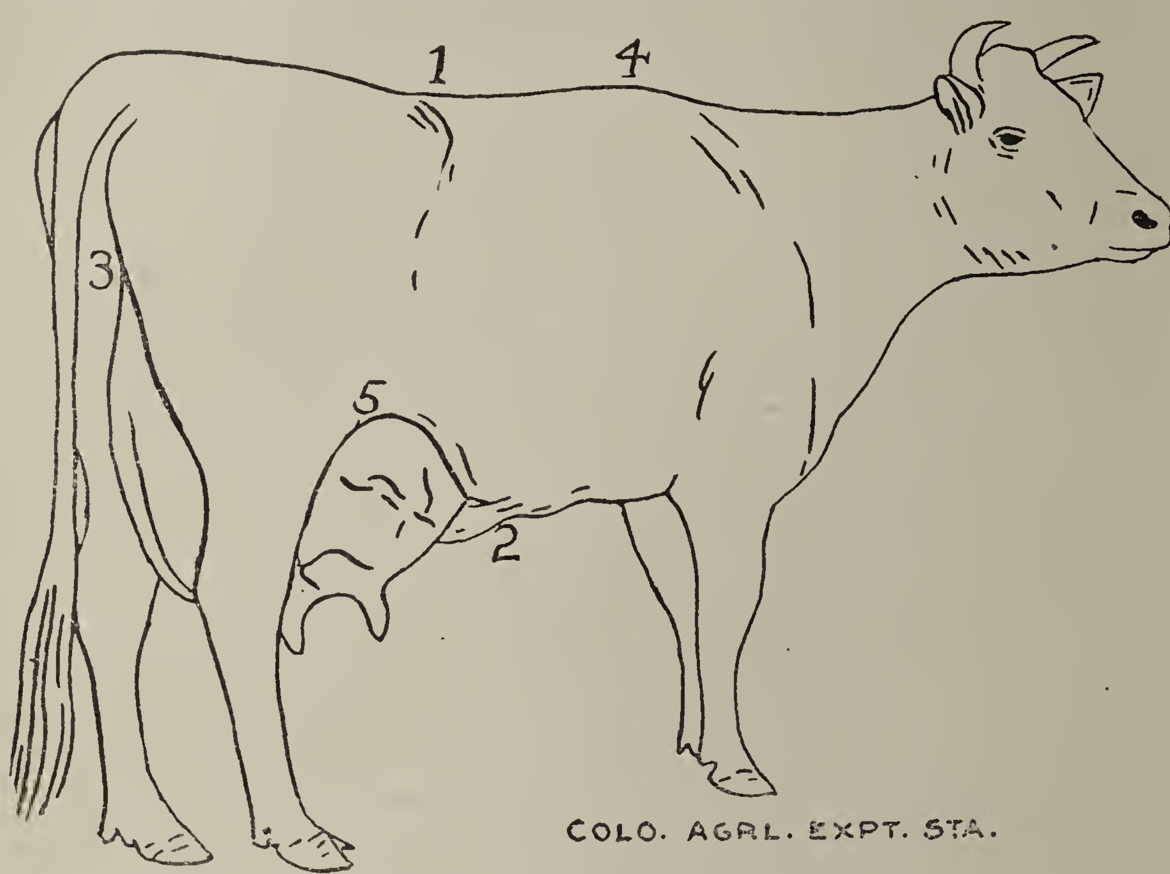
1. *Great Stomach Capacity.* The dry land farmer can feed little grain and his cows must daily eat large quantities of grass or roughage to be profitable. This requires ample room for storage, and to secure it the cow must be deep from back to belly, in front of the hip bones, and broad in the same region. Avoid a round bodied cow whose ribs are short and a flat ribbed cow. The ribs should be long and well sprung, providing for a large paunch.

2. *The cow's back should be sharp* and have little flesh when she is in good condition. When the feed is used to put thick flesh on the back, as is the case with beef cattle, it can not go to produce milk in the udder. The neck, shoulders, rump and thighs should be thin fleshed in the well fed animal.

3. *Ample room for the udder* and a capacious udder when the cow is fresh. The cow should be well cut up behind between the legs so that the udder can extend well up toward the root of the tail. The flank should be well arched, instead of level, as in the beef cow, giving room for the udder, and the udder should extend well forward

and not hang down. The milk veins should be large and the farther they extend forward the better. It is essential that the milk wells, the openings through which the milk veins pass into the abdomen, should be large, as large as the end of one's middle finger. The udder should be loose and pliable, when empty—not fleshy.

4. *The eyes should be large and bright and project out well from the face.* This is a strong indication of the nerve force needed for strong digestion and large milk secretion.



The dairy cow should be deep and wide from 1 to 2 as this gives her large capacity for rough feed. The back, from 1 to 4, should be sharp, with little flesh, when she is in good condition. She should be well cut up behind so that the udder can extend well up, as at 3. Her flank should be well arched, as at 5, to provide room for a large udder.

Where a farmer has handled beef cattle and is not sure he can recognize these features when he sees them, he should go to town and examine several cows that are known to be heavy milkers and verify each point.

Feeding the Cow.

The native grasses of the Plains are good milk producing feeds when abundant. Where sufficient land can be obtained, it pays to have a native grass pasture exclusively for winter use, keeping off all stock during the summer. In the winter of 1907 a new settler in Elbert county had a good winter pasture of native grass, but no other feed for his cows. He sold through the winter an average of four dollars' worth of cream per cow each month. He could not have done this with scant pasture nor poor cows.

Alfalfa is the best dairy feed and the dry land farmer should get

a field on his farm as soon as he can. Corn fodder raised in the high altitudes of eastern Colorado is a good milk producing feed, entirely different from the coarse product of the corn belt. The fodder from kafir corn and sorgum makes a good dairy feed if cut after the plants have headed, and not later than when the seed begins to harden. A full supply of ripe sorghum seed will soon dry up a cow. All fodders should be cut and cured to keep the leaves as green as possible. Hay from wheat, oats or beardless barley makes a good milk feed. The crop should be cut when the seed is in the thick milk and cured with as little exposure to the sun as possible. If there is a low place on the farm upon which the surface water from the unbroken fields can be carried by a few furrows, plant it with stock beets. Feed 10 to 20 pounds per cow daily. Crushed barley, ground wheat and the grain of milo maize are the dry land grains for dairy feed.

A daily variety in feeding forage crops will secure a larger milk yield than the method of feeding one kind exclusively for several weeks and then another. The most profit comes from feeding all the cow will eat every day. Five cows full fed will yield more profit than ten or fifteen cows sparsely fed. Feeding should begin early in the summer or fall before the cows begin to shrink in their milk.

Handling the Cow.

The cow needs in winter a warm, dry shelter, free from draughts. This can be made of straw, or of sod walls and straw or sod roofs, if lumber can not be afforded. Bales of straw will last for years, when used for stable walls, if the top of the walls are protected from rain. The cows in summer should have a shelter from the sun. This should be placed on the highest point in the pasture and can be made by setting up posts and putting over them a straw roof built so high that the cows can not eat it. Such a shelter will furnish shade and will be cool when the wind blows through it.

About 87 per cent. of milk is water, and the cow, to do her best, must have all she wants easily accessible. Salt should be kept in a box where she can eat it at will. Whatever adds to the comfort of a dairy cow increases the yield; discomfort decreases the yield. Kindness increases the milk yield and costs nothing. The more a milker can make a cow love him, as she loves her calf, the more milk she will give. Petting is profitable. The cow should never be driven faster than a slow walk. All feed should be given after milking as the dust from the feed contains the germs which sour the milk. Feeding and milking should be done at exactly the same hours, morning and night. The cow should be milked ten months each year, and on the Plains it is best to let her go dry through February and March.

It will usually pay the new settler to sell the calves for veal, and give all the feed he raises to the cows giving milk, as this will secure the quickest cash returns. A good calf may be raised on skim milk and either shelled corn, the whole grain of milo maize or crushed

barley. The grain should be fed dry and not mixed with the milk. Calves need plenty of water.

Handling the Cow's Products.

It will pay to separate the cream from the warm, freshly drawn milk with a hand separator. Cleanliness and cold are the necessary means to keep cream sweet. All utensils touched by the milk should be washed clean and scalded. No dust or dirt should be allowed to fall into the milk, as they contain the germs which cause souring. The cow should be milked in a clean place, and her udder and flanks should be clean. Ordinarily cream will keep longer when a covered pail is used in milking. To keep the cream cool, it should be kept either in a pail hung just above the water in a well or else the pail should be covered with a cloth kept wet by having one end dipping into water. Water will rise through the cloth, and constant evaporation will keep the cream cool. The cream should be sold to a creamery.

In May, 1908, the farmers at a point 90 miles from Denver, received nineteen cents a pound for butter fat, while farmers at a point 50 miles more distant received thirty-one cents a pound. The farmers receiving the lower price took the offer made by one firm and did not ask for competitive bids. The farmers receiving the higher price secured prices from four competing buyers. Denver, Colorado Springs, and Pueblo are good cream markets, and the producer should search for the responsible buyer who will pay highest.

Twenty dry land farmers around Elizabeth, Elbert county, made an average of $50 per cow per year feeding no grain, but with alfalfa hay. Burke Potter, on a 320-acre dry land farm, at Peyton, received $1,550 in one year for the cream from sixteen cows and six two-year old heifers, and sold veal calves for $50. He has well-bred Holsteins. He paid $300 for bran, and grew all the rest of his feed. With well selected range cows, properly fed and handled, the dry land farmer should average from the sale of cream from $30 to $50 per cow per year.

POULTRY ON DRY LAND FARMS.

The expert Colorado poultryman who thoroughly understands his business and gives strict attention, obtains an average of $2 per hen per year above cost of feed. Every dry land farmer should keep from 100 to 400 laying hens. He will not be able to get as much from them, but his expenses will be less, as a large part of their feed without them would be waste. The hens should be cared for by the farmer, and not by his over-worked wife. They should be fed and cared for three times a day, comfortably sheltered, kept free from vermin and the houses cleaned daily. If the dry land farmer will make a business of poultry, they can be made to bring him several hundred dollars each year. Cash, whether there is a drought or not.

The most money is in eggs from a special egg producing breed and strain. Egg laying strains of general purpose breeds come next in order for profits.

The average Colorado poultry raiser says that his chickens eat their heads off. His flock is a mixture of all ages, all colors and all breeds. Each breed needs a different treatment. Feed that will make a lazy Plymouth rock fat and worthless will stimulate an active Leghorn to heavy laying. The feed required by a laying pullet to provide for both eggs and growth will ruin a three year old hen.

Severe culling is the first step towards profit. Experts estimate that the average Colorado flock produces an average of sixty eggs per hen each year and that where the poorer half of such a flock is culled out, the average will rise to 120 eggs per hen, per year. Culling is particularly important to the new dry land settler, as he needs to make every ounce of feed return a profit, and he can not afford to feed unprofitable poultry.

In the average flock there are old hens that lay none, or few eggs, roosters that are not needed and usually late hatched or stunted pullets that lay little and eat much. These culls usually make up half or more of the flock, and the good layers have to support them.

Feeding Poultry.

During a considerable part of the year hens on the farm will pick up enough waste feed to supply them, but they should be watched every day and fed whenever the waste supply is short. Wheat should form half the ration for the hens, and the other half can be a mixture of milo maize, barley, corn and oats.

When hens do not get all the worms and insects they want they must be fed meat. Meat meal is the cheapest form in which meat for poultry can be bought. Often rabbits are trapped and fed cooked Hens need meat in some form daily, but in moderate quantities. Over feeding is shown by looseness of the bowels. It is a common custom to throw the offal at butchering time where the hens can get it and to let them feed on the carcasses of dead cattle. Almost always in these cases, hens will over eat sufficiently to reduce their egg yield, and if they have not had meat for sometime, will gorge themselves to such an extent as never again to be profitable. This meat is likely to taint the eggs and the flesh. Skim milk and curd will take the place of meat.

Poultry should have access at all times to oyster shells and hard, sharp grit. The Maine Experiment Station found that a laying hen consumed four pounds of oyster shells and two pounds of grit a year. Often it is necessary to buy grit on farms where there is an abundance of gravel and sand, but none with sharp, grinding edges.

Poultry should have all the clean, pure water they will drink at least three times a day. A general cause for well fed hens not laying is lack of water. Sixty-five per cent. of the egg and fifteen per cent.

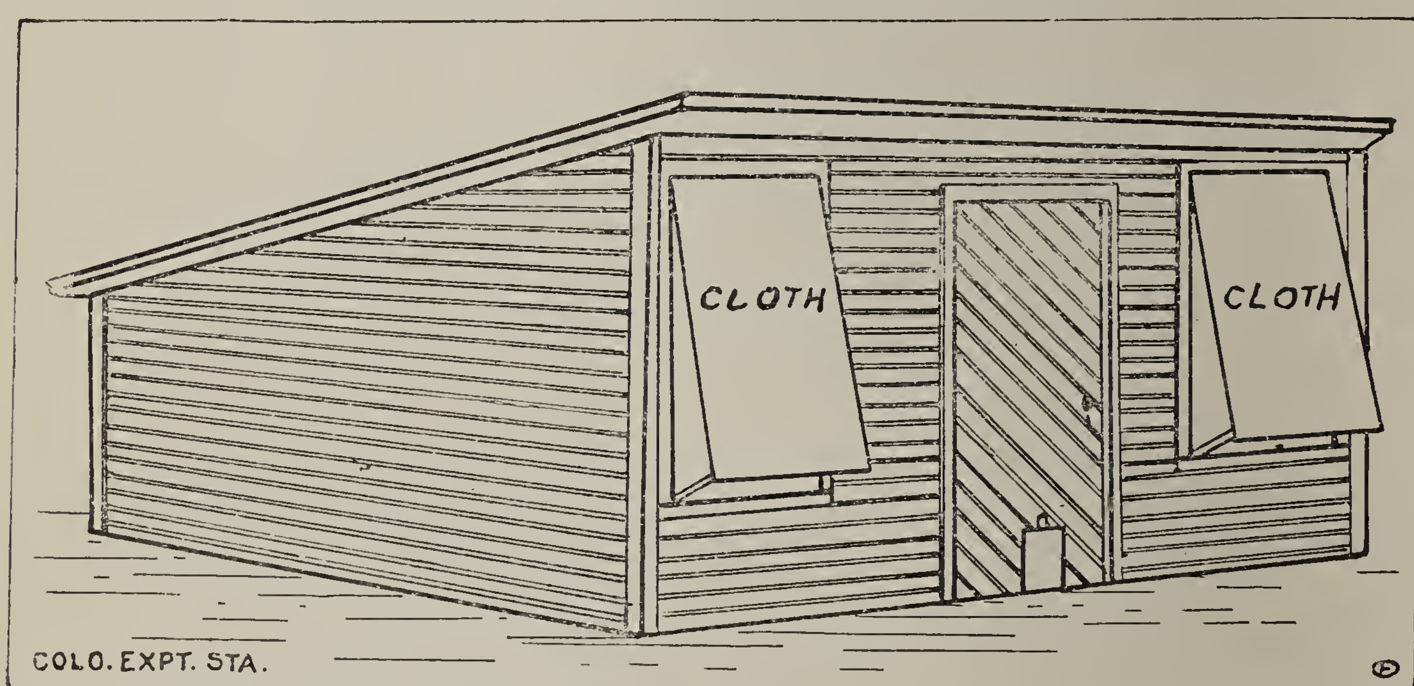
of the hen's body is water, and to lay she must have all she wants, whenever she wants it, and a full supply is necessary in digesting the feed. The chill should be taken off in winter, and the hens watched to see that three times a day they get all they will drink before it becomes frozen. Eating snow is a quick way to stop laying, and walking in the snow will promptly cut down the hen's egg yield.

The hen needs some kind of succulent feed every day; grass, alfalfa leaves, roots, potatoes, cabbage, sprouted grain, or even green sorghum. Too much will make the bowels loose and cut down the egg yield. Just enough should be fed each day to cause the droppings to be similar to those when the hen has the run of a field of grass.

Few good poultrymen feed wet mashes. It pays to warm the grain in winter.

The Hen House.

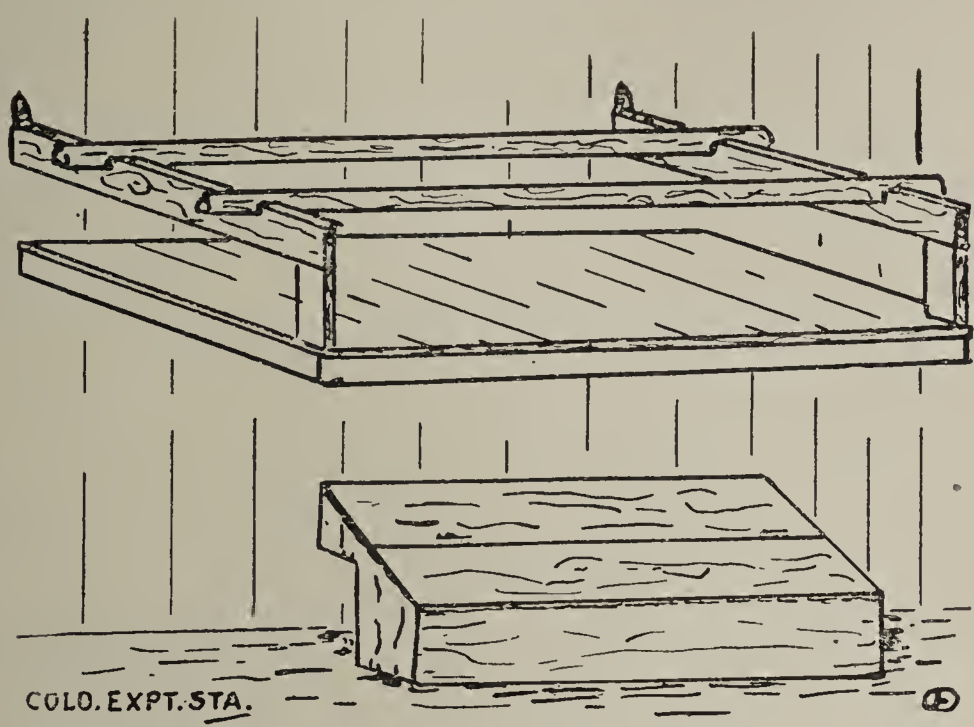
The house for hens should be warm, well lighted, dry and well ventilated without draughts. The dry land farmer can use lumber, sod or straw in building it, and get equally good results from his hens. Good dimensions are four and one-half feet high at the back, seven feet high in front, and fourteen to sixteen feet wide, with a shed roof. It is not best to keep over fifty hens in a house, and thirty to forty hens will give better returns The length of the house will vary with the number of hens kept in it. If two roosts are used, allow five inches in length of house for each hen. If three roosts are used allow three and one-half inches in length of house per hen. Under this rule a house for 40 hens should be about 16 feet in length if two roosts are used, and 12 feet when there are three roosts.



Poultry house for 40 hens, 14 feet wide, 16 feet long, 4½ feet high at the back and 7 feet high in front. No openings except in front. Window frames covered with cloth and hinged at top so that they may be pushed out at the bottom, on warm days. A small slide door at the bottom and center of the large door permits the hens to pass in and out.

All roosts should be on the same level and should not be over

thirty inches from the floor. The roosts should be about two inches wide and flat on top with rounded edges. A dirt floor, raised a few inches above the ground outside to keep out water, is as good as boards in the dry climate of the Plains. Eight inches below the roosts should be a tight dropping board to catch the droppings and they should be raked off each day into a basket and taken away from the house. The dropping board can be made cheaply from dry goods boxes.



Roosts and Dropping board with nests underneath. The hens enter the nests at the back and when on the nests are in darkness. The top over the nests is sloping so that the hens cannot roost on it and is hinged so that the eggs may be easily reached.

The important point in Colorado is to secure thorough ventilation in the hen house without draught. The average daily change in temperature each twenty-four hours is twenty degrees, and with such a great change it is difficult to ventilate through tubes or open windows without draughts. A draught on a hen is sure to cut down the egg yield, and usually brings disease. To prevent draught, have the house face the south. Make the north side, roof, and east and west ends without openings or cracks of any kind. Use heavy muslin in place of glass for windows. The air will circulate through the cloth without any draught, and light will pass through as well. Arrange the nests so that when the hens are on them, they will be in the dark. Keep the eggs in a cool, dry, dark place.

Hens on the treeless plains need cool shade in summer; sunflowers, trees or any low straw shed open on the north and south sides will supply this.

Lice and Mites.

Lice and mites thrive particularly on the Plains, and a persistent fight has to be made against them the year round. The dropping

board below the roosts should be cleaned daily, and the whole house once a week. The hens should have a good dust bath always ready, and two or three times a year the house should be white-washed inside, and carbolic acid mixed with the white-wash. Insect powder or tobacco dust dusted on and worked down through the feathers to the skin will kill body lice. Applications of boiling water or lice killer to the roosts and to all the woodwork, and particularly in the cracks, will kill the mites. Scald the nests with boiling water, as the lice killer will taint the eggs. Dr. J. W. Downey, one of the best poutrymen in Colorado, makes a good lice killer by crushing moth balls and dissolving them in kerosene. The liquid from this mixture is very inflammable and must not be used where there is a light of any kind. It is as effective as the patent lice killers and much cheaper.

It takes hard, intelligent work to make money from poultry on the Plains, but if the new settler is willing to give the necessary attention, he is sure to have the money with which to buy the family groceries whether it rains or not. Even with every pound of feed purchased, a good poultryman can make money in Colorado, and in most years the dry land farmer can provide most of the feed.

THE DRY LAND GARDEN.

The garden should be located where it can be irrigated from the well or where storm water from the prairie can be brought onto it by means of furrows. The patch should be small and should be given much cultivation. In most soils a garden can not be irrigated by taking water directly from the pump to the ground. A few square feet of ground will absorb water as fast as an ordinary windmill can deliver it. The water must be collected in a tank or earth reservoir, and then turned on in a considerable sized stream that will flow the entire length of the rows.

When ready to irrigate, open a narrow furrow along the entire length of the row and a short distance from it. Pull a straight round post through this ditch, to smooth the ground, and then run the ditch full of water. Apply the water after sundown, as it will do more good then, and the next morning thoroughly cultivate the soil, making a good earth mulch.

Mr. J. E. Payne, Superintendent of the U. S. Dry Land Experiment Station, Akron, Colorado, recommends that all garden crops be planted in rows and thoroughly cultivated. He recommends planting the usual small truck and a good patch of Mexican beans, early cow peas, sweet corn, potatoes, pumpkins, squashes, melons, and Pearl or Queen's Golden pop corn. He recommends planting seven varieties of sweet corn: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentlemen, Mammoth Evergreen and Egyptian. He plants all varieties the same day, often near the last of May, and has had roasting ears from July 26th to September 26th. "Sweet corn can be dried; the ripe grains parched are a luxury, as is popcorn

and milk. Poultry will keep the grasshoppers down, and potato and squash bugs may be killed by a club. A constant fight against them is necessary."

Early Richmond Cherries resist drought well and the fruit ripens while supplied with spring moisture. Set them 20x20 feet apart. Prof. B. C. Buffum recommends horse radish and rhubarb as among the strongest drought resisters. Mr. Payne states that gooseberries, native currents, plums and cherries are reasonably sure to produce good crops if given special care.

RAIN FALL IN COLORADO.

Records furnished by Prof. L. G. Carpenter, Director, Colorado Experiment Station, Fort Collins.

TOWN AND COUNTY	No. Years Record Kept	Average Inches Rainfall 3 Winter Months	Average Inches Rainfall 3 Spring Months	Average Inches Rainfall 3 Summer Months	Average Inches Rainfall 3 Fall Months..	Average annual Rainfall, Inches	No. of Years Rainfall was below average..	Least Rainfall in One Year ....
Rocky Ford, Otero	19	1.13	4.10	5.50	2.11	12.84	11	6.93
Denver, ...	39	1.62	5.53	4.27	2.53	13.96	18	8.48
Hamps, Elbert	15	0.91	5.21	6.15	1.69	13.96	10	7.62
Fort Collins, Larimer	25	1.37	6.24	4.63	2.63	14.87	13	7.11
Cheyenne Wells, Cheyenne	15	0.93	5.27	7.88	2.35	16.43	6	8.41
Le Roy, Logan	19	1.46	6.06	6.72	2.44	16.68	11	7.34
Yuma, Yuma	18	1.70	6.05	7.63	2.41	17.79	8	10.34
Wray, Yuma	14	1.09	6 43	8.29	2.85	18.66	5.	10.74

HANDLING THE SOIL.

Only the principles of handling the soil can be given. Their application will vary each year on every farm and with each crop. The dry land farmer's success will depend upon his skill in applying them to each individual crop.

The best soil for dry land farming is a sandy loam, then a light clay loam, and next a sandy soil. An adobe soil is to be avoided, as is also one with a coarse gravel subsoil.

The soils of the Plains are rich in mineral plant food. Often the subsoil, to a depth of thirty feet or more, will produce good crops when brought to the surface. The yield of the crop is determined by the quantity of available water which passes through the plant. Often when the rainfall is ample for a full crop, none is raised because the soil is in such condition that the rain can not be absorbed and the water runs off into the streams. Frequently when the soil has absorbed a plentiful supply of moisture to produce a good crop, the yield is unprofitable, because a soil mulch has not been provided, and the water is lost through evaporation.

WATER USED BY CROPS.

Prof. F. H. King concludes from his researches and from those of other investigators that an average of three hundred and twenty-five pounds of water must pass through the plants, and be evaporated by them, for each pound of dry matter which they produce. The weight of an inch of rainfall on an acre is one hundred and thirteen tons. In a crop of wheat grown on dry land, there is about the same weight of dry matter in the straw as in the grain. On this basis, one inch of water passing through the plants is sufficient for about five bushels of wheat per acre.

Under fair dry land conditions, at least three-fourths of the annual rainfall evaporates from the surface and runs off into the streams, with most skillful management this leaves not to exceed one-fourth of the rainfall to be absorbed by the plants. An annual rainfall of twelve inches, falling at the right time, and carefully conserved, would, under most favorable circumstances, furnish three inches of water to be actually used by the plant—sufficient to produce fifteen bushels of wheat.

It is evident that the production of fifteen bushels of wheat per acre, or the equivalent in other crops, from an annual rainfall of twelve inches, hangs on slender chances. Where the ground is hard or has been plowed too shallow to absorb water well, the run off is large. In some seasons the total rainfall is ample, but does not fall during the growing season, or it comes in heavy, driving showers, so fast and so hard that even mellow, deep soil can not absorb it as rapidly as it falls. The earth mulch may be carelessly maintained, and then the evaporation from the surface of the soil may amount to much more than three-fourths of the rainfall. The seed may be shiftlessly put in, the plants so thick in places that a good supply of moisture is insufficient and so thin in other places that they can not use all the moisture.

On the other hand, the plowing may be so deep and the soil kept in such good tilth that under ordinary conditions much less than one-fourth of the rainfall will run off and a greater proportion left in the soil available for the plant.

Four things are necessary to secure profitable crops with the limited rainfall of eastern Colorado:

1. Storage of rainfall.
2. Retaining moisture in the soil.
3. Reducing the effects of the wind.
4. Drought resisting crops from seed grown under dry land conditions.

STORING RAINFALL.

Much of the rainfall runs off the surface of the compact, unbroken prairie of the Plains. The earliest need is to put the soil in such tilth that it will absorb a large part of the rainfall, even when it comes

in dashing showers. To do this it must be broken and porous, to a depth of at least a foot, and in granular condition—neither loose nor puddled, and with no large air spaces. The surface must be kept corrugated. A soil in this sponge like condition not only absorbs water well, but allows a wide spread of the roots, giving to each plant a large water-supplying area.

The raw prairie is broken the first time at any depth from three to nine inches, depending on the power available and the toughness of the sod. It should be gradually deepened until the practical limit of the ordinary plow is reached. All the land should be plowed, no cutting and covering, and the furrow should be turned over flat and pressed firmly down on the unbroken soil to promote quick rotting. If the plow is followed with a disc harrow, running lengthwise of the furrow, the rotting of the sod is hastened. The soil gets into condition most quickly when the prairie is broken after the grass has started well in the spring and while it is still growing.

One of the cheapest ways to deepen some soils it to take advantage of the effects of frost. Just before the ground freezes in the fall, list it, going as deep as the lister will work and making the rows not over three feet apart. The furrows will soak up all the moisture that falls and the ground will freeze deeper than it would if left level. On warm days the large surface of exposed soil will thaw and in cold nights freeze. This alternate freezing and thawing granulates the soil, putting it in the best condition for absorbing moisture.

The listed ground must be leveled and protected with a soil mulch as soon as the frost is out, as the evaporation from the large surface made by listing will be much greater than with level land.

In twenty-one years of observation on the Plains the writer has never seen any increase in yield with any kind of crop from subsoiling land. The soil does not stay loose long enough after being subsoiled to be benefited. Where a farmer thinks that subsoiling will help his land, he should first test it on a small scale.

Using deep rooted plants, such as alfalfa, brome grass and sweet clover, is a cheap method of deeply loosening hard soils and thereby improving their water-holding capacities.

Decayed plant and animal matter increases the water-holding power of the soil, and the dryer the season the stronger its influence. This material gives the soil a dark color and is very deficient in the soils of the Plains. The more the decayed roots of plants and the material from rotted manure is incorporated into dry lands soils, the greater will be the proportion of rainfall that is absorbed.

It is specially important for storing moisture in dry land farming that every pound of manure produced on the farm should be spread on the fields, and yet most dry land farmers find that when they manure the land, the crop is reduced, sometimes for several years. When coarse manure is plowed under, it cuts off the connection between the

plowed and the unstirred soil, making a mulch that prevents the water from rising through the plowed land, and it creates large air spaces in the soil. These tend to dry out the soil rapidly and to weaken the plants growing in it.

All manure used in dry land farming should be applied as a light top dressing to grain, grasses or alfalfa. It then acts as a mulch, helping to retain moisture in the soil. The finer particles are imperceptibly absorbed by the soil, the harrowings required by these crops slowly work the manure into the soil without making air spaces and the manure becomes as great a help as it is a detriment when plowed under unrotted.

RETAINING MOISTURE IN THE SOIL.

When dry land soil has been loosened to a good depth to form a reservoir, and it is porous and fine grained, the water from a rain slowly moves downward through it until absorbed, and each minute grain of earth becomes covered with an invisible film of moisture.

When these minute grains of soil are in close contact with one another, there is a constant movement of the water in the films surrounding them, the water flowing from a wet grain to a dryer one. After a rain the sun and the wind dry out the surface soil and carry away the moisture contained in it. Then the water from the damper soil below moves upward to wet the surface grains and is in turn evaporated. This movement continues in land not cultivated and extends to a depth of many feet, often, in a dry time, taking out of the soil, in a week moisture equal to more than an inch of rainfall.

When the surface soil is stirred after a rain, the tiny grains are separated so that the water does not easily pass from one to another. The movement of the moisture is checked and evaporation is greatly reduced. Such shallow cultivation is called an earth mulch, because it has a similar effect in holding the moisture in the soil, as that effected by a mulch of straw or a covering of boards.

The dry land farmer's supply of moisture for his crops depends upon his skill and judgment in maintaining an earth mulch over his cultivated fields. No set rules can be given. He should study the principles governing the absorption and movement of water in the soil, as here given, until he thoroughly understands and appreciates them. Then he can intelligently conduct the farm operations for maintaining the earth mulch.

The deeper the earth mulch, the better it will prevent evaporation from the soil. For cultivated crops a general rule, with many exceptions, is to keep the mulch three inches in depth. With trees, four to six inches is better. Seeds must be planted below the earth mulch so that they will be in moist soil and the mulch must not be so deep as to prevent the young plants from coming up. With growing wheat and other grains, the mulch must not be made so deep as to put the roots in dry soil.

A good rain packs the loose surface soil and destroys the earth

mulch. It is necessary to pulverise the ground quickly after every such rain to restore the earth mulch, as a week's delay may mean the loss of water equal to an inch of rainfall. Light showers do not usually destroy the mulch.

On account of the winds, evaporation is very rapid just after the frost goes out of the ground in the spring and an earth mulch should be established as soon as the ground is dry enough to work. Evaporation is very rapid from stubble fields after the grain has been cut, and an earth mulch should be made with a disc harrow as soon as the grain is shocked.

Where the surface is hard, the earth mulch will have to be made with a disc harrow; where the surface is mellow, a spike toothed harrow will pulverize the soil sufficiently. A four-horse disc harrow should be used for economy of time. A man having five horses attached to a twenty-four foot spike tooth harrow can put a mulch on thirty to sixty acres a day.

When the annual rainfall drops much below twelve inches and the rainfall during the growing season below five inches, it is difficult, and often impossible, to raise a profitable crop. The land can be fallowed one season and cropped the next, the one crop having the use of what moisture can be stored from two years' rainfall. During the season that no crop is raised an earth mulch must be maintained, and to do this it is usually necessary to till the surface about every ten days, and always after any considerable rain.

In many seasons paying crops may be secured by this system, where, if an attempt is made to grow crops every year, the failure will be total for both years.

With this system the dry land farmer who has one hundred and sixty acres under cultivation will each year have eighty acres in crops, and eighty acres which he will have to till regularly, but upon which nothing will be growing. In Logan county a farmer has been quite successful in following a modification of this plan. He raises three crops in four years. The first season no crop is grown, but the land is kept thoroughly cultivated. In the fall, winter wheat is sown. After harvest the ground is immediately disked, and, as soon as convenient, plowed and harrowed. The following year corn is planted and well cultivated, the cultivation in part having the same influence as a summer fallow. The following year wheat is grown, and the next year the rotation is started again with a summer fallow for the whole season.

Weeds act as pumps constantly at work taking the water needed for the crops out of the soil and evaporating it into the air.

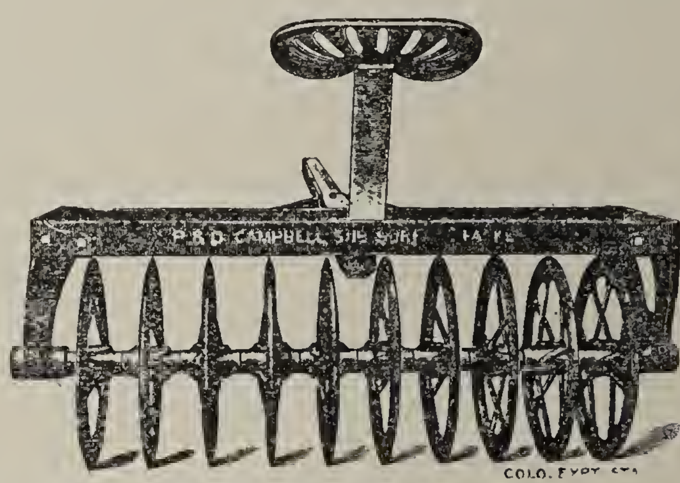
SUB SURFACE PACKING.

Usually on the Plains when soil is turned over with the plow, it is so dry that an imperfect connection is made with the unstirred ground beneath, and the soil that has been broken up by the plow

acts as an earth mulch and prevents the moisture rising above the bottom of the furrow. Unless rain comes, the ground that has been turned by the plow soon becomes so dry that plants will not live in it. It is a good system to thoroughly disk ground just before plowing. The surface turned under will then be fine and will better form a good connection with the soil below.

Dry soil, clods, trash and coarse manure, when turned under by the plow, will make air spaces in the pulverized soil. The air in these spaces dries out the soil and increases the losses from evaporation.

To retain the moisture in the pulverized soil, to bring it up from below to the roots of the plants and to drive out the excess of air, freshly plowed soil must be firmed until a compact but mellow condition is secured. The best implement so far devised with which to do this is the Sub Surface Packer originated by Mr. H. W. Campbell.



The sub surface packer consists of a number of sharp rimmed iron wheels, twenty inches in diameter, placed five inches apart on a strong shaft mounted in a suitable frame. The packer follows the plow, going lengthwise of the furrow. The sharp wheels fine the soil near the surface where the seed is planted and firmly packs the earth against the bottom of the furrow and around the trash and manure,—just the condition needed for a good seed bed and for the best control of the moisture.

The writer considers the sub surface packer one of the most indispensable implements for dry land farming, and would not attempt dry land operations without it. One hundred and sixty acres were plowed for wheat, eighty acres prepared as thoroughly as could be done by harrowing and eighty acres fitted by packing. The yield on the harrowed ground was eighteen bushels per acre, on the packed ground forty bushels.

Whenever the soil is sufficiently moist to settle quickly, it is not necessary to use the packer, but it should be at hand for use when needed. It is heavy in draft, an eight-foot machine requiring four good horses.

Sub surface packing can be fairly well done by setting the disks straight on a disc harrow and weighting the machine to cut deeply.

A corrugater roller is a fair sub surface packer, though not nearly so effective as a machine with sharp rimmed wheels.

With good management in storing the rainfall and in holding it in the soil, the earth will be kept moist from the bottom of the mulch to a depth of 8 to 9 feet.

REDUCING THE EFFECTS OF THE WIND.

A dry land country is always a land with much wind, and the dryer the season the steadier and the harder the wind blows.

The first principle for reducing the damaging effect of the wind is to keep the surface of the ground corrugated. Engineers, in measuring deep mountain streams, often find that where the water is moving so swiftly on the surface that a man can not stand against it, there is almost no current at the bottom, where the velocity is checked by stones. It is on the same principle that the surface of dry land should be kept corrugated; the uneveness impedes the motion of the wind.

When freshly plowed dry land soils are rolled with a smooth roller, the wind moves as fast along the surface of the soil as it does at the height of a man above it, and will often sweep the soil off the field as deeply as it has been plowed.

The sub surface packer leaves the ground more deeply corrugated than the grain drill. The packer wheels have iron spokes, and while the rim fines and packs the soil, making a good seed bed, the spokes bring small clods to the surface, and packed ground has both the corrugations and the clods to retard the wind. The writer has many times seen a highwind blowing across a field that had just been treated with a sub surface packer, and a little fine dust only would be sifting around the clods and across the low ridges, while from adjoining fields, left smooth, the dust was rising in clouds.

All grain should be drilled in with the furrows running at right angles to the prevailing winds.

Deep fall plowing, left rough, will carry land through the winter with reduced losses from blowing, especially if the lower soil that is turned up is a little heavy. An earth mulch must be made on fall plowed ground as early in the spring as it can be worked to save the moisture.

The dry land farmer will find it profitable to start wind breaks and shelter belts around his buildings and garden as soon as his farm gets on a living basis. It sometimes pays to have them on the north, west, and south sides of the farm to check the wind's force. Professor Longyear, of the Colorado Experiment Station, recommends using two year old seedling trees, planting them eight feet apart each way. The two outer rows to consist of Russian olive, the third and fourth rows of black or honey locust, the fifth and sixth rows of ash, the seventh and eighth rows of American Elm or Golden Russian willow, and the two inner rows of cottonwood or Carolina Poplar.

Full directions for the planting and after treatment of forest trees may be obtained by writing to the Director of the Colorado Experiment Station, Fort Collins.

CROPS FOR DRY LAND FARMING.

It is imperative that the seed used on the Plains should be grown under arid conditions. It is best to use seed that has been grown in the neighboorhood where it is to be planted. If this is impossible, the seed should be grown under as dry conditions as will be met by the growing crop.

This fact can not be emphasized too strongly. Even a small increase in the amount of moisture will lessen the power of plants to withstand severe drought. In a dry year in the "nineties" the writer inspected a field of corn on a farm where the line fence was on the State line between Colorado and Kansas. The stalks were green and well eared, while for over one hundred and fifty miles east, corn was generally a failure. The seed used was a local strain that had, by selection, been developed to yield well under local dry conditions. The grower stated that every time he had tried seed from even only one hundred miles farther east, the crop had been poor.

It is the common practice for new dry land settlers to bring their favorite seeds with them. The Iowa man brings seed corn, the Indiana man oats, and the Michigan man potatoes. With seasons of average or lower rainfall, the planting of these eastern seeds guarantees a failure. The root development of plants from eastern seed is not sufficient to enable them to spread far enough in dry land soil to gather enough moisture, and often the too great growth of foliage evaporates too much moisture.

Only those grain crops that mature early, before drought and hot winds come, and before the spring moisture is exhausted, should be grown. Wheat, barley and speltz are such crops. The surest forage crops are those like sorghum, milo maize and kafir corn that live and stand still through a drought and then mature quickly when rain comes. Seed should be selected from plants whose large root systems give them a broad area from which to draw moisture.

Every season it is likely that conditions on the Plains will be unfavorable before the season is over. This condition demands seed with strong vitality that will transmit vigor to the young plants as soon as they start. Heavy seeds, as a rule, give strongest growth and the thorough use of a fanning mill with plenty of air is a great aid in securing a crop.

Dry land farmers are usually careless about seed and use a mixture of heavy, shrunken and cracked grains, weed seed, chaff, sticks and dirt. There is much loss from seed that has been heated.

Thin seeding is necessary. Where there is moisture enough to mature one plant only, if two occupy the space, the crop is a failure.

When in doubt about the quantity of seed needed, use one-half the amount customary for humid sections.

The following pounds per acre are suggested, but the amount should vary with the size of the seed and the condition of the soil:

Wheat, 30 to 40.
Barley, 35 to 50.
Speltz, 45.
Flax, 20.
Millet, 10.
Sorghum drilled for forage, 25.
Kafir corn, drilled for forage, 25 to 30.
Milo Maize, for grain, 5 to 8.
Corn, single seeds, 15 to 18 inches apart.
Dwarf Essex Rape, 3 to 5.
Brome Grass, 20.
Alfalfa, for hay, 12 to 20.
Alfalfa, cultivated for seed, 2 to 3.
Sweet Clover, 20 to 25.

Early seeding should be the rule, so as to take advantage of the moisture released when the ground thaws out and from that furnished by early rains. The development of the native vegetation is a good guide to the time for seeding.

Broadcasting has no place in dry land farming. It is a sure method of wasting seed and of producing many weak plants. Some seed is certain to be put in too deep and more too shallow. All seeds should be drilled and great care should be taken that single seeds are placed at equal distance apart. In careless drilling, where seed is bunched, there is not enough moisture to develop the plants, and the moisture in the bare spots is wasted. The writer has examined fields of corn in dry land sections where in every row there were spaces between stalks of from 5 to 13 feet, and other places where the corn was in bunches too thick to amount to anything. Wheat is often seeded as carelessly, and such planting insures a serious reduction in the crop no matter how favorable the season.

It is self-evident that a good seed bed is essential in dry land farming, and yet it is common practice to put seed in cloddy, dry and loose soils.

Sorghum is the surest drought resisting crop. The yield is from nothing to seven tons per acre, depending upon the condition of the soil at planting, the character of the seed and the rainfall. Early Amber is generally used. The seed may be put in with a grain drill, at the rate of 25 pounds per acre, or listed shallow, six pounds of seed per acre, and cultivated until the furrows are level full. It grows very slowly at first and should not be seeded until the ground is warm, usually May 10th to June 15th. Seeded earlier the weeds get ahead of it. Sorghum should not be cut until the seeds begin to harden. When cut before it heads, sorghum is chiefly water and some vegetable fibre, and while very appetizing, furnishes little nourishment to stock. In years of plenty, sorghum can be stacked and kept until needed in times of drought. A cheap but rather wasteful way for harvesting it is to turn the cattle into the sorghum field when the seeds have become firm. Such a method of fall feeding will hold dairy cows up well in their milk. The cows should be well fed before being turned into the sorghum and left only one hour the first day,

two hours the second day and so on. Sorghum makes a fair pasture for hogs during the summer. A dairy cow fed all the ripe sorghum hay she will eat, and no other feed, will soon go dry. It is a fair dairy feed when supplemented by other fodders.

Kafir corn, the surest dry land grain crop in Kansas and Nebraska, does not mature anywhere on the Plains of Colorado except in Baca county. The high altitude makes the nights too cool and the seasons too short for kafir corn as a grain crop. It is planted for forage the same as sorghum.

Dwarf Milo Maize has the same habits and characteristics as kafir corn, but will ripen in a shorter season, and is probably the surest grain crop for the dry lands of eastern Colorado. It should be tried by every farmer, as it will probably fill the same place in dry land farming that corn does in the corn belt.

On ground well filled with moisture it may be planted with a grain drill in rows thirty-two inches apart, dropping single seeds four to six inches apart in the row. In dryer land it may be listed after the ground becomes warm, from May 10th to June 15th, dropping single seeds the same distance as above. The drill and the lister should be followed with a press wheel to pack the soil over the seed. Milo maize is a sorghum without sugar, the strength of the plant going to produce seed.

The seed should be kept in the head until just before planting. Threshed seed stored in bins or in sacks, even when kept dry for a year, is likely in a few damp days to become sufficiently heated to badly injure its germinating power. Where not over forty acres are to be planted, the heads may be held on a sloping board in a wash tub and the seeds scratched off with a common curry comb. The ripest and the most vigorous seeds will shell off first, and when half the seeds have been rubbed from a head, it may be thrown aside and fed to stock. With this method, only the best seed is secured. It should be cleaned free from stems and chaff before planting.

Milo maize should be given frequent shallow cultivation, the same as corn. When ripe is should be cut and shocked like corn. Th-- may be done either by hand, with a corn sled or with a corn binde- In winter the fodder with the heads may be fed to cattle and horses and the scattering grain picked up by either hens or hogs. Fattening hogs do better when the grain is threshed and fed to them either soaked or ground. Work horses fed milo maize can do as much heavy work in the spring and summer as they can on corn. It is best to top the fodder and feed the grain to work horses in the head. When eating milo maize in the head, the little stems that hold the seeds compel the horse to eat slowly and chew the grain well. When threshed grain is fed, the horse is likely to bolt his feed.

One hundred pounds of Milo Maize have a feeding value equal to ninety pounds of corn, and a fair yield is forty bushels an acre, equal in feeding value to thirty-six bushels of corn. The objection

to milo maize as a feed is that it is constipating and stock after a few weeks feeding on it suffer in consequence. This may be overcome by feeding some alfalfa or flaxstraw, the oil in the few seeds left in the straw acting as a laxative.

The plants of sorghum, kafir corn and milo maize develop large root systems, much larger than corn. This enables each plant to secure moisture from a comparative large area. When a drought comes, these crops live but stand still for weeks, and if late rains come, start quickly and mature seed.

Millet gives a fair yield in seasons where the rainfall reaches the average or above. It is a cheap crop to grow and to harvest and on this account is liked by many dry land farmers. The German millet is the best yielding variety when the rainfall is good. The Broom-corn millet withstands drought best. Millet should be cut as soon as it comes into head, as the ripe seeds are detrimental to stock.

Early cut millet makes a fair feed for cattle, and its laxative effect is beneficial to cattle being fed sorghum, kafir corn or milo maize. Millet hay containing ripe seeds will quickly dry up a dairy cow. Millet, no matter at what stage it is cut, is a dangerous feed to give horses. If fed long, it will stiffen horses so that they will never recover, and often causes their death.

Corn. In years of average rainfall corn is a valuable forage crop in eastern Colorado, and when moisture is abundant, yields a moderate crop of grain. On account of the altitude, the seasons are too short and the nights too cool for large crops. Corn fodder raised at this high altitude is an excellent dairy feed, entirely different from the coarse product of the corn belt.

Seed developed on the Plains must be used; that from the corn belt will not yield much grain in years of heaviest rainfall and in dry years often does not even produce fodder. Frequently new settlers from Iowa and Illinois will send back for seed for three or four years, and every year have a failure before they are willing to accept this fact.

The Plains bred corn has a short, rather sturdy stalk, limited in foliage, and the ears grow close to the ground. The Mexican corn stands the drought best. The ears start at or below the ground, and the variety is objectionable on this account. The White Australian Flint is generally preferred. It is a local variety, bred to withstand drought well, and the ear is similar in character to the eight rowed flint corn of New England. The grain is very hard and needs to be soaked or ground for feeding. The Swadley Dent and the Colorado Yellow varieties have ears similar in size and type to the Pride of the North Corn of Minnesota. They are prized in many localities.

A fair crop of corn on dry land is from 10 to 25 bushels per acre, and this yield is considered profitable on account of the high price of corn in Colorado and the low expense of raising a crop.

Corn and Milo Maize need similar methods of planting and

cultivation, and when the dry land farmer can afford the teams and the implements, one man can handle large areas and reduce the cost per acre for raising so low that even a small yield is profitable.

One man and three heavy horses with a single lister can prepare the ground and plant eight acres a day. Following the lister with a smoothing harrow has never seemed to the writer to be profitable, although generally recommended. About all the harrow does is to drag trash on to the rows.

For the first three cultivations, one man driving four heavy horses on a disc harrow can cultivate twenty acres a day, straddling alternate rows, and each cultivation straddling the row that was on the outside the previous cultivation. Guards are needed to protect the corn when small. One man driving four heavy horses to a three-row lister cultivator for the first three cultivations can handle well thirty acres daily. With both the disc harrow and the lister cultivator, the corn should be laid by with an ordinary corn cultivator. The crop can be harvested at the rate of seven acres a day with a three-horse corn harvester.

Wheat is the cash crop of the Plains, but fails too often to be depended upon to meet living expenses. It is safe to calculate on at least two failures each five years. Sometimes there will be failures for two or three years in succession, and then as many paying crops. It is probable that in many sections the greatest profit could be made by alternating summer fallow with years of cropping.

The ground should be plowed early for wheat, and each half day's plowing harrowed before the teams leave the field. After plowing, the land should be worked with a sub surface packer and then harrowed frequently. Wheat needs a shallow firm seed bed, very mellow above the seed.

Turkey red is the variety preferred for fall seeding, and Kubanka Durum for spring seeding. Early seeding is usually necessary to secure a good yield. The seed should be heavy and well graded and sown with a drill.

In the spring, if the ground is loose, run over it with a sub surface packer. If the ground is firm so that many plants are not loosened, harrow across the drill rows. Begin harrowing as early as the ground will work well, and continue, at intervals of ten days, until the plants shade the ground.

When wheat, after heading, begins to burn up from drought, it may be cut for hay and makes a good feed for horses and dairy cows.

Barley requires a short season and a good supply of moisture for early growth. It should be seeded with a drill as early in the spring as the danger from severe frosts is over. Barley is more sensitive to frost than either wheat or oats, but if the ends only of the leaves are killed, the plants are not hurt. Often the moisture released when the frost goes out of the ground is nearly sufficient for barley up to heading time, when the seed is sown early.

A large share of the failures in growing barley come from late seeding. The seed is sown after the moisture held by the frost has been lost, making the early growth weak. The barley then heads too close to the ground to harvest.

Two varieties are used for dry land farming; California Feed barley, and the Bald. The Bald barley is one of the best drought resisters, but the straw is weak near the head and with a good yield much of the grain falls down. California Feed barley is the best yielding variety in seasons of good rainfall.

Oats is a poor dry land crop; very uncertain in yield. Many farmers sow oats, and if the drought is so severe at the time of heading that the heads will not fill, the crop when in bloom is cut for hay. The hay is excellent for horses and dairy cows. Kherson and Sixty Day are the varieties usually recommended.

Speltz, or Emmer, as it is correctly called, looks like a cross between barley and wheat. In threshing, the chaff remains attached to the grain. It is a strong drought resisting plant, and the grain is a good feed for horses, cattle and sheep. The grain contains too much hull to be a hog feed. Sow with a drill, the same time as for barley, using forty-five pounds of seed per acre.

Flax, so far as tested, has proved to be a good dry land crop when the rainfall reaches an average, and a total failure in years of severe drought. In Lincoln county, in 1907, in large fields, the yield on sod was nine bushels per acre, and on summer fallow, twenty-two bushels per acre. In the same locality, in 1908, much of the acreage was not worth harvesting.

It is one of the best crops for putting sod in mellow condition for the crop which follows it. It should be sown early as it needs abundant moisture to push the young plants. Sow with a drill using twenty pounds of seed per acre.

Flax straw is a good cattle feed as it contains some seeds and the oil in them is needed to balance the deficiency in fat found in most dry land crops.

Dwarf Essex Rape has been described as a cabbage that keeps growing, but never forms a head. It stands cold and drought well, if sown as early in the spring, as the ground can be worked. Late seeding is a total failure in dry years.

Sow in rows twenty-four inches apart, using three to five pounds of seed per acre. Cultivate frequently. It is the next best pasture to alfalfa for hog feed. The hogs should be turned on the field when the rape gets eight to ten inches high. It is best to divide the field into two lots and change the hogs from one to the other as they eat the crop down.

Potatoes, if given special attention, can be grown most seasons on dry land farms where the soil is not heavy. In 1908, in a section of Kiowa county that produced no marketable grain, a farmer grew one hundred bushels of potatoes per acre on two acres. The patch

was on high land at the foot of a slope where it received the storm water from over twenty acres of prairie. The land was plowed about twelve inches deep, and furrows arranged to catch the surface water from the land above. The soil was thoroughly pulverized before planting and repeatedly harrowed and cultivated. A farmer in Phillips county reports good yields for eight consecutive years. He harrowed and cultivated the potatoes at least twelve times each year, and his fields received the surface water from land above.

Potatoes on dry land require early spring planting, strong seed covered firmly with moist soil, and repeated cultivation. Early Ohio and Rose Seedlings are the varieties generally recommended.

When potato bugs are too numerous, Prof. C. P. Gillette, of the Colorado Experiment Station, recommends the mixing of one pound of Paris green with fifty pounds of flour. Place the mixture in a sack of cheesecloth and shake the sack over the vines when the leaves are damp.

Stock Melon is a large citron, with firm flesh, that keeps well into the winter if protected from freezing by straw or earth. It is a passable substitute for roots and furnishes a much needed winter succulent feed for cows, hogs and poultry. It withstands drought well and a moderate quantity should be grown by every Plains farmer. Plant and cultivate the same as for watermelons.

HAY CROPS.

Wheat, oats and *bald barley* cut when the seeds are in the milk and cured with as little exposure to the sun as possible make good hay for horses. *Fodder* from corn and kafir corn will take the place of hay for work horses, care being taken not to have it dusty when fed. Horses will stand heavy work such as breaking prairie, when fed grain and fodder, but fodder is disagreeable to handle in mangers.

Brome Grass (*Bromus inermis*) is the most satisfactory drought resisting grass that has been tested on the Plains, and is generally recommended by those who have given it a careful trial under dry land conditions.

Most of the seed on the market has been heated, and but a small per cent. will germinate. The writer has always sown twenty pounds per acre, and has never yet secured a good stand nor seen one from seeding made by others. Brome grass spreads from the roots, and if the stalks are not over one foot to eighteen inches apart when first seeded, the stand will thicken to a good sod in a few years.

Select low land which receives storm water from land above and have the soil deeply plowed, thoroughly pulverized and well settled before seeding, with a good supply of moisture stored in it. Seed with a drill. The seed is chaffy and is very difficult to sow, requiring two men, one to drive and one to see that the seed works down steadily.

Keep down the weeds and wait with patience until the stand

thickens to a good sod. Brome grass furnishes good hay until the sod gets too thick and then will stand heavy pasturing. It gives early and late pasture and is often dormant in midsummer.

Alfalfa should be tried on most farms on the Plains. Select a low spot or a place at the foot of a long slope where surface water from the rains can be carried to it by furrows. Do not plant on sod. Raise other crops until the sod is thoroughly subdued.

Plow the ground deeply. Thoroughly pulverize and pack it and do not seed until the soil is moist to a depth of seven to nine feet, if you have to wait two or three years. While waiting, work the soil often and collect in it all the moisture you can from land above.

Alfalfa will usually fail when sown in freshly plowed land. Plow deep but get the soil well settled before seeding. Sow with a grain drill, using twelve to fifteen pounds of seed as early in the spring as the danger from severe frosts is over. Use no nurse crop.

Use seed grown on dry land. Seed from irrigated land is certain to bring a total failure, and a great proportion of the failures in eastern Colorado have been assured from the start by the use of seed from irrigated fields.

Prof. W. M. Jardine, U. S. Department of Agriculture, told the writer that in Utah a dry land strain of alfalfa had been developed that with an average annual rainfall of eleven inches yielded an average of two tons of hay per acre. Seed grown under such arid conditions finds eastern Colorado most congenial.

When one year old, alfalfa should be harrowed early in the spring and again after each cutting.

When two years old, and every year thereafter, alfalfa should be thoroughly cultivated with a disc harrow set to cut two to three inches deep. The alfalfa should be disked early in the spring and after each cutting.

Alfalfa should be cut as soon as the first blooms appear. It will live many years longer than if left until in full bloom before cutting. Alfalfa must not be pastured so close as to have the crowns eaten off; when this is done, the plants die.

Usually when alfalfa is seeded on dry land for the first time, it dies out in three or four years. The land should then be plowed and planted to another crop that can be thoroughly cultivated. At the end of one year reseed to alfalfa, using the same methods as employed for the first seeding. The second seeding usually thrives for many years as the first sowing has prepared the land to a good depth for the easy growth of the second seeding.

Prof. P. K. Blinn, of the Colorado Experiment Station, has made a special study of alfalfa and has prepared the following statement for this bulletin:

RAISING ALFALFA FOR SEED IN DRY FARMING.

If a farmer on the dry plains has a well that will furnish just enough water for fifty head of stock, it would be absurd for him to

try to keep sixty or seventy-five head on the same supply of water; and it is equally ridiculous for him to attempt to crowd plants in soil where the moisture is limited.

Some plants may develop with less moisture than others, but alfalfa is not one of these plants; on the other hand, it is conceded by all western farmers that an abundance of moisture is the key to success in growing alfalfa for hay.

When it is well established, alfalfa will endure long droughts and still revive when water is applied; to that extent, it is adapted to "dry farming," and its deep rooting tendency may enable the crop to grow without irrigation, if the roots can penetrate the moist soil.

There are some localities on the Plains where the run-off from heavy showers could be collected and diverted by ditches upon soil suited to alfalfa. Often in a draw, where moisture from the surrounding prairie is inclined to center, good encouragement for seeding to alfalfa is offered.

The number of plants to the acre that can be maintained in the dry farming district has not been determined; but at Rocky Ford, Colo., in 1908, an alfalfa nursery plat, without irrigation for eleven previous months, produced at the rate of two and three-fifths tons per acre the first cutting; and then made a second growth, equally as good, that was left for seed. The plat had been seeded, in1907, to Turkestan alfalfa, and thinned to single plants twenty inches apart each way. It received one irrigation and was thoroughly cultivated that year. In 1908 the growth was made from the moisture that was stored and conserved in the soil; but such phenomenal yields can hardly be expected without irrigation. In the favored spots, before mentioned, alfalfa can certainly be grown if once established and properly managed.

The growing of alfalfa seed offers great opportunities to the farmer on dry lands, because the fact has been well demonstrated that alfalfa yields seed best when the plant makes a slow, dwarfed growth, when it really lacks for moisture, but has enough to set and fill the seed.

Seed grown under dry conditions has more vigor and vitality than seed produced with an excess of moisture, and it is usually free from dodder and other noxious weeds, if the field has had any cultural care. There is a demand for dry land alfalfa seed that far exceeds the supply.

In establishing alfalfa for seed production, under dry conditions, it is recommended to sow in rows eighteen or twenty inches apart, with two or three pounds of good seed per acre. A thin, uniform stand is absolutely necessary, even to thinning, as in beet culture, but the stand can usually be regulated by the amount of seed sown.

It has been found that plants twenty inches apart will support each other and not lodge or lay on the ground, as in thicker or thinner stands. With a good stooling variety like the Turkestan, plants six

to twelve inches apart in the row are thick enough. If all the seed would germinate, one pound per acre would be ample, but it is difficult to sow a small quantity uniformly in the row, and for seed production, it might pay to space and thin the plants.

The row system is essential, as it permits inter-tillage to eradicate weeds, and to conserve the moisture, and also allows deep cultivation to absorb winter storms, affording an opportunity to furrow out the rows and direct or divert any surface water that may or may not be needed. It is the only system that will allow the tillage that is so essential in all dry farming.

The four-row beet cultivator, with its weeding knives and other attachments, is an ideal tool for cultivating the crop. A four-row drill, adapted to sowing alfalfa seed, is needed to complete the equipment, but the ordinary beet drill, with the addition of an alfalfa or grass seeder attachment, can be modified to suit the work.

The seed should be sown shallow, not over an inch deep, and good results have been secured with the common garden drill by marking out the ground with the rows gauged in sets of four, to correspond to the four-row cultivator.

Where there is an opportunity to use flood water for irrigation the field should be ditched in every other row, and the furrows logged out with a sled made of short logs, eight to ten inches in diameter, and from three to four feet long, spaced to fit two furrows, so that the water may run through as quickly as possible, for the alfalfa crop for seed will need only a small application of water. A short rush of water after a sudden shower can be delivered over considerable ground if the field is properly ditched.

IMPLEMENTS AND POWER.

The yield under average dry land conditions is low and a large acreage must be handled per man in order to make a living. This requires a number of heavy horses and implements of large capacity. A man with two horses will hardly average plowing two acres per day. The same man with five or six horses and a gang plow can plow an average of five or more acres a day. The returns from his labor are two and a half times greater with the larger equipment. Riding implements are always preferable because with them a man does not get so tired that he can not think.

A breaking plow for sod should have a mould board either solid or of rods. A disc plow does very poor work in sod.

The mould board plow is preferable for old ground, except when the soil is so dry that it plows up in clods. A disc plow will turn over land very dry and hard without making clods. Extra shares should be purchased with each plow, as sharp shares save power.

The lever smoothing harrow should be twenty-four feet wide, in four sections, with the coupling bars so arranged that two, three or four sections can be connected as desired. With five or six heavy horses on a 24-foot harrow, a man can till thirty to sixty acres a day.

A riding attachment adds little to the draft and much to the comfort of the man.

A disc harrow is essential. It should cut at least seven feet wide and be operated with four horses. The disc harrow can be used to pulverize sod; cultivate corn, milo maize and sorghum; put a mulch on alfalfa fields, on stubble fields after harvest, and on ground in the spring. It makes a fair sub surface packer when weighted and the disks are set straight.

A four-horse sub surface packer is the most economical.

A lister is needed for planting corn, milo maize and sorghum for grain. With three horses and a single lister, a man can plant an average of seven to eight acres daily.

The most economical grain drill sows either eleven or thirteen feet. It should have single discs and easily removable press wheels that are coupled in pairs, each pair working independently.

The two-horse corn cultivator should have both broad and narrow shovels. The one-horse cultivator should have at least nine reversible teeth and be narrowed and widened with a lever.

A home made float is very useful when land is cloddy. A wagon and hay rack, a mower and a two-horse hayrake and small tools are needed. The grain binder and corn harvester can usually be hired to advantage. One good fanning mill is sufficient to grade the seed for a neighborhood.

GRASSHOPPERS UPON THE PLAINS.

Grass hoppers are often a serious pest. When the native grasses become dry, a cultivated spot of green plants attracts them from every direction. Many failures have been due to this cause alone.

A large flock of turkeys affords a good protection. One turkey per acre for the entire farm where half is under cultivation, will save the crops. The birds are herded on the fields during the day time and shut up in a wolf-proof enclosure at night. In the fall they are closely confined while being fattened.

Prof. C. P. Gillette, of the Colorado Experiment Station, advises remedies in press bulletin 38. This may be had on request of the Director.

"One of the simplest and often a very effectual remedy is to grow plenty of chickens or turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect the crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

"Hopper 'dozers' or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112."